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CONCLUSION OF SIXTH GROUP.

ELECTRICITY, MILITARY AND LIFE-SAVING MATERIALS.

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REPORT

ON

ELECTRICITY

(CLASS 62),

BY

CARL HERING.

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REPORT ON ELECTRICITY.

By CARL HERING.

In the following report the writer has endeavored to give a general description of the more important exhibits, accompanied by comparisons, opinions, histories of their development, summaries of the progress shown, statistics, and in general such information as will indicate the extent and importance of this class at the exhibition, and the present state of the art as represented by this exhibition.

This being the first universal international exhibition held since the practical beginning of the development of this great industry, it was of interest to notice the place it took among other industries, and the part it played in making the exhibition attractive and instructive. Owing to the absence of exhibits from a number of different countries, the exhibition in this class was not as international as might have been desired, though the number of foreign exhibits was by no means small. For this reason the exhibits cannot be said to represent the true state of the art, except in such branches in which the French excel. The industry was, however, very well represented, and, as far as France was concerned, it was very complete. In general it was quite large, very interesting, and instructive.

It was to be regretted, for several reasons, that this industry, which in the United States ranks among the largest of the country, did not receive the prominent place in the grouping of the exhibits that it demands. In grouping it, the same classification was adopted as in the exhibition of 1878, when it may be said to have hardly commenced its development. The present importance of this industry demands that it should be made a separate group, in order that it may receive the attention and prominence which it deserves. It is strongly urged that in future exhibitions the old classification should be altered, giving this subject the rank of a group instead of a class.

EXTENT AND RELATIVE IMPORTANCE OF THE EXHIBITS FROM DIFFERENT COUNTRIES.

The following compilations will give an approximate idea of the relative importance a :d extent of the exhibits from the United States in this class, as compared with those from other countries.

The number of exhibitors in this class were as follows:

France, about	360	Chile	2
United States	28	Uruguay	2
Great Britain	19	Germany	1
Belgium	13	Japan	1
Switzerland	8	Luxemburg	1
Russia	5	Norway	1
Portugal	4	Finland	1
Austria	3	Argentine Confederation	1
Mexico	3		
Italy	2	Total	455

In a total of 455, France had 360, leaving 95 foreign exhibitors. Of these the United States had 28, which is therefore about one-third of all the foreign exhibits. England comes next, having one-fifth. France had 79 per cent of the total number of exhibitors; United States, 6.2; Great Britain, 4.2; Belgium, 2.8; Switzerland, 1.8; Russia, 1, and the rest together, 5 per cent. It is to be regretted very much that Germany was practically not represented in this class at the exhibition.

Of the fifteen members of the electrical jury, France had 10; United States, 2; Great Britain, 1; Switzerland, 1; Belgium, 1. Besides this, there were 5 supplemental jurors: France had 3, Great Britain and Belgium, each 1.

The floor space occupied by our electrical exhibits was 967.25 square meters, or, in round numbers, about 1,000 square meters. That of the French section was about 2,000 square meters, not including the eight or ten stations distributed about the grounds for lighting. The floor space occupied by the other foreign countries can not be determined with accuracy, owing to the fact that the exhibits were together with numerous others, and were very much scattered about the grounds. From an estimate, however, it appears that Switzerland comes next, with 210 square meters, then Belgium and then Great Britain, with 60 square meters, the others being quite small. The space occupied by the United States was somewhat greater than that of all the other foreign countries combined. However, the importance of an exhibit is by no means proportional to the space it occupies. Neither will the number of exhibitors represent the importance of an exhibit. These figures merely give an approximate idea of the extent of our exhibits as compared with that from other countries.

A better comparison of the real values of the exhibits may perhaps be had from the number and nature of the awards made by the jury, as that eliminates entirely the space occupied, and in a

measure also the number of insignificant exhibitors. The awards made by the jury were as follows, in order of their value: Grand prize, gold medal, silver medal, bronze medal, and honorable mention. Now, the mere total number of awards given to the different countries would by no means represent the value or importance of the exhibits from those countries. It is absolutely necessary, if any summation at all is to be made, to give the different awards some definite relative values. Such a relative scale is difficult to determine upon, as it is almost entirely a matter of opinion. Different persons have entirely different views regarding it, depending on what award they received or did not receive, as well as on the award which their neighbor received. It is certain, however, that an arithmetic scale of relative values of 5, 4, 3, 2, 1 does not express the relative values of the different awards. The importance of the higher awards increases much more rapidly. A geometric scale would give much truer values, and therefore the following scale will be assumed here as representing a fair average value: Grand prize, 20; gold, 10; silver, 5; bronze, 2; honorable mention, 1. By multiplying the number of the awards by their respective values on this basis, the totals obtained can then be assumed to give their relative values.

The awards made to electrical exhibitors in the different countries, and their relative values on this basis, were as follows:

	Order of succession.	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total relative values.	Total relative values in percentage.	Percentage of number of exhibitors.
France	1	6	30	48	58	67	843	65.2	79
United States	2	4	6	4	2	2	166	12.8	6.2
Great Britain	3	1	4	4	3	2	88	6.7	4.2
Belgium	4	.....	5	3	2	1	70	5.4	2.8
Switzerland	5	1	3	2	2	1	65	5	1.8
Russia	6	......	2	......	2	1	25	1.9	1
Germany	7	......	1	......	......	......	10		
Luxemburg	8	......	1	......	......	......	10		
Japan	9	......	......	1	......	......	5		
Uruguay	10	......	......	......	2	......	4		
Italy	11	......	......	......	1	1	3	3	5
Finland	12	......	......	......	1	......	2		
Austria	13	......	......	......	......	1	1		
Portugal	14	......	......	......	......	1	1		
Norway	15	.	......	......	......	1	1		
Total	......	12	52	62	73	78	1,294	100	100

It will be seen also from the above that the United States has one-fifth as much as France, twice as much as England, and about two and a half times as much as Switzerland and Belgium. It has four times as many grand prizes as any other foreign country, more gold

medals and as many silver as any other. It received one-third of all the grand prizes, and about 12 per cent of all the gold medals.

As far as awards are concerned, there were nineteen exhibits from the United States. Eighteen of these, or 95 per cent, were awarded as in the above table, 21 per cent received grand prizes, 32 per cent gold medals, and 21 per cent silver medals.

The awards were as follows (in alphabetical order):

Grand prize: American Bell Telephone Company, Edison, Elihu Thomson, Elisha Gray.

Gold medals: American Graphophone Company, Cobb Vulcanite Wire Company, Heisler Electric Light Company, Okonite Company, Sprague Electric Railway and Motor Company, Western Electric Company.

Silver medals: Commercial Cable Company, Consolidated Telegraph and Electrical Subway Company, Elektron Manufacturing Company, Sperry Electric Company.

Bronze medals: Electrical Supply Company, Solar Carbon Company.

Honorable mention: American Nickel Works (Wharton), Munson Lighting Conductor Company.

Some idea as to the importance of the electrical exhibits, in comparison with the other exhibits from the United States, may be had from the number of grand prizes awarded in the other classes. There were in all fifty-three grand prizes awarded to United States exhibits; four of these, or 7.6 per cent, were for electrical exhibits. One class received nine; two classes, four; one class, three; five classes, two; twenty-three classes, one. But this is not a fair comparison, as twenty-seven (over half) of the grand prizes were for public institutions and government exhibits. Eliminating these, there remain twenty-six grand prizes to companies, manufacturers, and inventors. Out of these, electricity was the only class receiving four, or 15.4 per cent. Four other classes received two each and fourteen classes one each.

Among the great successful inventions in the practical application of electricity, the United States may claim the telegraph, the telephone, the incandescent light, and unquestionably the microphone* also; France, the accumulator and the Gramme ring; Italy, the battery and the Pacinotti ring; England, the self-exciting dynamo; Germany, the drum armature; Russia, the commercial arc lamp.

PROGRESS.

One of the objects of a report of this kind is to give a summary of the progress made in this industry and science since the last inter-

* Although Hughes made the invention in England, he had lived the greater part of his life in the United States and had obtained his whole education here, which led him to the invention.

national exhibition, taking as the present state of the art that represented by the present exhibition. In this particular class, however, this would be difficult and unsatisfactory for numerous reasons. If the International Electrical Exhibition at Philadelphia in 1884 is taken as the last exhibition prior to this, it would not give a basis for the progress made in Europe, as this exhibition was international in name only; there were scarcely half a dozen foreign exhibits. If the electrical exhibition at Vienna in 1883 be taken it would not include America, as that exhibition was almost exclusively European. The development of the greater part of this great industry has been so recent that to go back farther than the Vienna Exhibition is to go back to the beginning. The last universal exhibition of 1878, in Paris, which is really the one which should be taken in such a comparative report, is too early for such a comparative report in this branch; the state of the industry at that time may be said to be limited to telegraphy, batteries, bells, electroplating, and a few dynamos. It may therefore be said that by far the greater part of the present large industry has developed since that exhibition.

Just about that time, however, and within a few years later, the telephone, the microphone, the arc light, the incandescent light, the practical systems of distribution of light, the accumulator, and other fundamental inventions, forming the present industry, began to come into use; this date may therefore be taken as representing about the time of the birth of the present large industry. A summary of the progress made since that exhibition is therefore simply a record of the present state of the art as shown by this exhibition, as almost all that has been done has been done since that date, excepting the few subjects mentioned above, which comprised the whole industry at that date. There are few, if any, industries of the extent of the present electrical industries that have made such wonderful progress in so short a time, not much over ten years.

As this class includes so many different branches, it was thought preferable to give short histories of their development in connection with the descriptive reports of each branch, rather than to attempt to summarize them here.

The present state of the art cannot be said to have been fully represented at this exhibition. Germany, Italy, and Austria, where much has been and is being done in this field, were very poorly represented, in fact were practically not represented at all. The exhibits from England, though very good, did not represent the great progress made there. From United States too, some important branches were not represented. Political prejudices unfortunately kept away many i .teresting exhibits—chiefly from Germany.

In France great progress has been made in telephony and telegraphy; in the former, because there are no fundamental patents to hinder progress, in the latter because it is under Government con-

trol. In electric lighting, however, progress has been very much hindered, in Paris at least, by the Government. In Paris the city government has granted to a syndicate a monopoly for the supply of gas; it receives in return one-half of the profits above 5 per cent. This income to the city last year was stated to be 12,000,000 francs (about $2,400,000). This makes it very much to the interest of the city to keep out as much as possible the competing electric light. As it can not, in the interests of justice, keep it out altogether, it has enacted laws, which, though not prohibitory, at least hinder its introduction very greatly. The municipal tax on a ton of coal in Paris is 1.20 francs (24 cents) for commercial purposes and 7.50 francs ($1.45) for private use. Electric lighting companies, however, have to pay the *latter* tax and not that for commercial purposes. If they place the stations outside of Paris and lead the current into the city, the energy is measured and taxed in proportion to the equivalent in coal. An authority states that his electric company must pay 5 per cent of their receipts (not profits) to the city for a station in the city, and 7 per cent when it is outside of the city. The charges of one of the companies are from 21 to 29 cents per kilowatt hour, which is about 16 to 21 cents per horse power of current; in Philadelphia, for instance, it is 7 cents per horse-power hour. The cost of gas in Paris is 30 centimes per cubic meter for the citizens and 15 for public lighting; this is equal to $1.64 and 82 cents per thousand feet. The latter is also the average cost in the provinces.

It was intended to include in this report statistics regarding the present extent of the industry; but in general this had to be abandoned as it was found impossible to obtain this information for the foreign countries; a few statistics regarding the extent of the electric light industry are, however, given in connection with that subject. The following general figures may be of interest here. The Proceedings of the Electric Light Association gives the following figures for the United States for the beginning of 1890: 2,700,000 incandescent lamps, 230,000 arc lamps, 500,000 horse power used for lighting; over 600 miles of electrical railroads completed and in construction; 750,000 miles of telegraph lines; over 120,000 miles of telephone lines. The following for the beginning of 1890 is taken from the Electric World:

The number of electric lighting companies in the United States and Canada operating central stations at the beginning of 1886 was 450. This number had increased at the beginning of 1887 to 750, at the beginning of 1889 to nearly 1,200, and at the beginning of 1890 to 1,277, including 25 in Mexico and Central America. Meantime 266 gas companies had engaged in electric lighting, so that the total number of companies engaged in electric lighting at present (1890) is 1,543 The number of isolated or private incandescent and arc light plants at the beginning of 1887 was about 1,000 each. Now there are 3,925 private plants in the United States, 175 in Canada, and 200 in Mexico and Central America, making 4,300 in all. The

number of arc lamps in use in 1882 was 6,000. This number doubled each year for four years, and has since grown rapidly until there are now 235,000 arc lamps in use. The number of incandescent lights has increased from 525,000 in November, 1886, to 3,000,000 at present. The number of electric motors now in operation in the country is estimated at 15,000, many of them from 15 to 50 horse power. There are nearly 200 electric railways in over 125 towns and cities, and these have in operation or under contract 1,884 cars on 1,260 miles of track.

CLASSIFICATION.

The exhibits included in this class are of such a nature that a rational classification in a report of this nature becomes very difficult. Numerous systems of classification adopted in other reports were considered, but all were found unsatisfactory for one reason or another. One of the best of these was the one proposed by M. Hospitalier, in l'Electrician (May 25, 1889), in which he divides the subject into: production, transformation, transmission, measuring instruments, and the various applications, thermic, chemical, mechanical, and miscellaneous. But although rational in so far that there is no doubt as to where an exhibit belongs, it brings together subjects like electric railroads and telephony which are really widely different, though both are "mechanical applications" of electricity. It furthermore separates batteries from accumulators and both from electrochemistry. The writer has, therefore, adopted a new classification, which might be termed a "natural" one, which brings together into each one of several sections those exhibits which almost always accompany each other and can not well be separated from one another—that is to say, those which would naturally be included in the scope of a specialist in any one broad field. It has been found that the exhibits can be examined and described much more readily when divided into such natural sections. It is suggested by the writer that the classification might perhaps be the most rational subdivision of the broad class "electricity" to be used at subsequent exhibitions both for grouping and for examination, as well as for a descriptive report and for cataloguing. Such a classification divides the whole class into five principal sections and a few smaller ones which do not belong to any one of the others, or else belong equally well to several of them. The first, largest, and most important includes electric lighting, power, dynamos, etc., which for want of a better name will here be called "*electrodynamics*," as it naturally forms a department in dynamical engineering. The second one in order of importance is *telegraphy and telephony*. The third, *annunciators, bells, and miscellaneous applications*, might perhaps have been included with the second, but as it forms a distinctly separate industry it was thought best to make a separate section of it. The fourth is *electrochemistry*, and the fifth, *measuring and scientific instruments*. The remaining ones in no special order of importance

are: (6) *thermogenerators;* (7) *wires and conduits;* (8) *medical electricity;* (9) *miscellaneous*, and (10) *general supplies.* The subdivision of these sections will be found in the index.

DESCRIPTION OF THE EXHIBITS.

In the description of the exhibits, which forms the greater part of this report, the writer has endeavored to give only brief descriptions, not burdened with details, except where such are necessary or of importance, novelty, or interest. Current literature in this branch is so good and so widespread that it may be assumed that specialists have already read descriptions better detailed than it would be possible to do in a report of this nature covering such a wide ground. The writer has therefore limited himself chiefly to giving a general summary of the chief features of the exhibits, more for the sake of comparison and as a record of the present state of the art as represented at this exhibition. Under a number of the special headings are given short summaries of the history or progress of that class of apparatus, and a summary of the latest developments exhibited. Whenever good descriptions in standard periodicals were known to the writer it was thought preferable to refer to them, and give here only short summaries of the articles, rather than to burden this report with copies of existing descriptions, which are readily accessible in any good library.

Descriptions, opinions, and comparisons have been given from the standpoint of an American, acquainted in general with American methods and systems, a general knowledge of which is assumed on the part of the reader.

It was endeavored to do justice to all exhibitors and also to inventors, by always giving the names, whenever the latter could be obtained. Also to state whenever possible the award which was given the exhibit. However, when no such award is mentioned, it does not necessarily mean that it was not important enough to receive an award. It may be that the exhibitor was not entitled to receive awards, being represented on the jury, or that the particular exhibit described was but a part of a collective exhibit for which the award was given.

It was intended to make this description as complete a summary as possible of the more important, interesting, or novel exhibits. In some cases, however, promised descriptions or references were not received; in others none could be obtained at all. In some cases the exhibits were installed too late to be catalogued, and of these some may, therefore, have escaped the writer's notice; others were classified in other classes, to which they more properly belonged, and it was, therefore, difficult to find them. In numerous cases the exhibitor feared piracy, and therefore hesitated and even sometimes

declined to give detailed information—in some cases even when descriptions had been published and all that was asked for was a reference to the publication. In most cases the exhibits were not accompanied by attendants, and all the information which could therefore be obtained was from inspection, from circulars, or correspondence, or descriptions in journals, references to which were, however, difficult to obtain. The difficulty of making a description was increased by the fact that it was forbidden by the exhibition authorities to make notes or sketches; these were confiscated when found. Much of the apparatus was in cases, without either an attendant or a description or a reference to the same.

There were numerous exhibits in which electricity was applied, which, however, belong more properly to other classes, because they are included in the scope of specialists in those classes and not necessarily in the scope of the specialist in electricity. These have been referred by the writer either entirely or in part to the other classes. Among these classes are railroads (signals), meteorology, metallurgy, implements of war, engineering, clocks, medicine, surgery, physical and physiological apparatus, etc. It requires specialists in those classes and not in electricity to properly appreciate and describe such applications of electricity.

In reducing prices to dollars the value of the franc was assumed as 19.3 cents and of the pound sterling $4.84. The word "here," frequently used in this report, refers to the United States and not to France.

JURY.

The jury of awards for the class 62, electricity, consisted of fifteen active members and five associate members, who were not entitled to vote. The names are as follows:

President: Professor Mascart (France), member of the Institute; Professor of the College of France; member of the jury of the Exposition in 1878.

Vice-President: William H. Preece (Great Britain), member of the Royal Society; Chief Electrician of the State Telegraph Department.

Reporter: Prof. A. Potier (France), professor of the National High School of Mines.

Secretary: Colonel Turettini (Switzerland).

Members from France: Messrs. Marcel Deprez, Hippolyte Fontaine, Fribourg. Huet, Postel-Vinay, Gaston Sciama, Col. Sébert, Trotin.

Belgium: Prof. E. Rousseau, Professor of the University of Brussels; member of the jury at the Exposition of 1881.

United States: B. Abdank, Carl Hering.

Associate members: Jousselin, Rau, Sautter, from France; Leon Gody, from Belgium; J. Aylmer, from Great Britain.

Of the fifteen active members, five (or 33 per cent) were from foreign countries, of which the United States was the only one having two members (or 13.3 per cent) of the whole jury. Owing to the large number of exhibits and the wide range of this class, the jury subdivided itself into the following sections: (1) Machines, transformers, instruments—Fribourg, Hering, Potier, Sciama, Turettini; (2) telegraphy, telephony, signals, cables, wires—Aylmer, Jousselin, Preece, Trotin; (3) lighting and accessories—Huet, Postel-Vinay, Rau, Rousseau, Sautter; (4) electro-chemistry, batteries, accumulators, bells, miscellaneous—Abdank, Fontaine, Gody, Hering, Mascart, Sébert.

The examinations were made chiefly by the individual sections, but in many cases the visits were made by the whole jury together, as also by members individually. Awards were recommended by the sections and were discussed and voted upon by the whole jury, at which meeting all but one of the members (Deprez) were present. The examinations made by this jury extended over a period of about two months.

Official tests of many of the dynamos were made by the members of the jury. Those of accumulators, cables, a few batteries, and arc lamps were made for and under the auspices of the jury by the Labratoire Central d'Electricité. Besides these, many individual tests and examinations were made and witnessed by the members. The tests were to aid them in their work, and the results are in general not for publication.

For a comparative list of the awards in this class in the different countries and classes, see page 11.

CONGRESS.

Organization.—An official International Congress of Electricians was held in Paris from August 24 to 31, 1889. The committee of organization consisted of Prof. Mascart, president; Messrs. Lippmann, Fontaine, and Gariel, vice-presidents; three secretaries; a treasurer, and twenty-two members, all of whom were from France, and were appointed by the French administration in July, 1888. At the opening, the following officers were elected: President, Mascart; honorary president, Sir William Thomson (Great Britain); vice-presidents, Ferraris (Italy), Kareis (Austria), Potier (France), Preece (Great Britain), Rousseau (Belgium), Stoletow (Russia), Weber (Switzerland); reporter, Joubert (France); director, Carpentier (France). The work of the Congress was divided into four sections, as follows: (1) units and measures; (2) industrial applications; (3) telegraphy, telephony, and signals; (4) electrophysiology.

Membership.—There were about five hundred and thirty members who took part, eleven of whom were from the United States; there were delegates from foreign governments and societies, from Belgium, Brazil, Chile, Spain, Sandwich Islands, Greece, Italy, Japan, Mexico, and United States.

Proceedings.—A few papers had been prepared by appointment to introduce the subjects, as also a list of suggestions of various subjects to be discussed and acted upon. Each section held from four to six meetings. As a very good summary of the proceedings was published officially by the administration and may be found in public libraries, it is not considered necessary to repeat it here. Most of this summary will be found very interesting. A complete set of the papers read, and the discussions, has been published by the administration. Some of the papers may be found in the various technical journals of those dates.

Units adopted.—The most important work accomplished was the unanimous adoption at the final general session of the following units and definitions:

Joule.—The practical unit of work is the *joule.* A joule is equal to 10^7 C. G. S. units of work. It is equal to the heat disengaged during a second by an ampère through an ohm.

Watt.—The practical unit of power is the *watt.* A watt is the power of a joule per second. It is equal to 10^7 C. G. S. units of power. The Congress expresses the wish that in practice the power of all machines, mechanical as well as electrical, be expressed in *kilowatts* * (=1,000 watts) in place of horse-power.

Decimal candle.—For measuring the intensity of a light in candles, the practical unit is to be a twentieth part of the absolute standard of light defined by the International Electrical Congress of 1884; it is to be called the *decimal candle.*†

Quadrant.—The practical unit of the coefficient of induction is the *quadrant.* The quadrant is equal to 10^9 centimeters.

Period.—The *period* of an alternating current is the duration of one complete oscillation.

Frequence.—The *frequence* of an alternating current is the number of periods per second.

Mean intensity.—The *mean intensity* of an alternating current is defined by the formula:

$$C_{mean} = \frac{1}{T}\int_0^T C dt$$

Effective intensity.—The *effective intensity* of an alternating current is the square root of the mean square of the intensity of the current.

Effective E. M. F.—The *effective electromotive force* of an alternating current is the square root of the mean square of the electromotive force.

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* One kilowatt equals 1,000 watts (as its name indicates), or 1.3592 metric horse-powers (or about four-thirds, within 2 per cent); or 1.3406 (English) horse-powers (or very nearly four-thirds, within one-half of 1 per cent). One metric horse-power equals 0.73575 kilowatt (or nearly three-fourths); one (English) horse-power equals .74594 kilowatt (or very nearly three-fourths).

† This decimal candle is very nearly equal to the English standard candle and to a tenth part of a carcel.

Apparent resistance.—The *apparent resistance* is the factor by which the effective intensity must be multiplied to give the effective electromotive force.

Accumulator plates.—In an accumulator the term *positive plate* is to indicate that one which is connected to the positive pole of a circuit during the charge and that which forms the positive pole during discharge.*

The Congress recommends, as a means to determine the degree of incandescence of a lamp, the method proposed by Mr. Crova and adopted by the second section.

The metallic circuit (double-wire circuit) is adopted for municipal telephone circuits and for lines connecting cities (interurban).

The term *interurban* is to apply to all telephonic communications between two subscribers or public stations forming parts of different groups.

The following was recommended by the section, but was not adopted by the Congress, on the grounds that it was of too administrative a character: The unit of interurban telephonic conversation is fixed as three minutes.

A communication from the American Institute of Electrical Engineers was presented through their delegates to the Congress, Messrs. Hering, Tesla, and Wetzler proposing that the next International Electrical Congress meet in the United States on the occasion of the coming International Exhibition in 1892.

CONCLUDING REMARKS.

In concluding these introductory remarks the writer can not urge too much that the very rapid growth of electrical engineering and its present great importance among the various industries, as shown by this exhibition, demand that it should hereafter receive a more prominent place in the classification and grouping of the exhibits at future exhibitions. It should, without question, be made a separate group, divided into at least two or three classes, in order that it may be given the prominence and attention which its importance demands. It is to be regretted very much that this was not done at the present exhibition, instead of retaining the old classification of 1878, at which time the application of electricity in the arts and industries was practically limited to telegraphy, batteries, and bells.

In conclusion, the writer desires to express his full appreciation and his thanks to Prof. Potier, of Paris, for his kind and valuable assistance in furnishing the writer with much valuable information, particularly regarding the French exhibits; also to Mr. B. Abdank-Abakanowicz; Prof. Mascart, of Paris; Mr. William H. Preece, of London; Dr. Palaz, of Losanne, and to the secretary of the National Telephone Company of London for important information and assistance in obtaining the same. To Mr. August Reeb, of the French Telephone Company, and to Mr. William J. Hammer, of

* Or, in the usual lead accumulator, the brown or peroxide plate.

the Edison Company, the writer is indebted for detailed information regarding their respective exhibits. Mr. J. Carpentier, of Paris, Messrs. Elliott Bros., and Messrs. Woodhouse and Rawson, of London, kindly furnish the cuts which accompany the description of their exhibits.

The writer desires also to acknowledge the kindness and courtesy of the French administration of the Exhibition.

I.—ELECTRODYNAMICS.

DYNAMOS.

GENERAL.

Historical.—The present commercial dynamo may be said to have been developed from experimental machines almost entirely within the past 12 or 15 years. Although the general principles were known, and the underlying inventions had been made a number of years before, yet as there was practically no great demand for dynamos they received little attention until electric lighting was begun on a commercial scale, when the demand became so great that much attention was given them. As there were no fundamental patents to hinder progress, keen competition soon developed the dynamo into a very good and efficient machine.

Progress.—Since this rapid development the progress has been slow but not unimportant; it has been mainly in the direction of finding the most advantageous proportions, rather than to find radically new forms. While the latter has been, and is, repeatedly attempted, yet most of them are abandoned for the well-studied and well-tried forms. Improvements have therefore been mainly in developing the best proportions and disposition of parts, and in details. The best machines at present are still in principle those of the original Gramme, Pacinotti, or drum armature types, though very materially changed in their proportions and in the more advantageous disposition of parts.

As is generally the case with the development of such complex mechanisms, extremes were tried in all the different proportions, until at present the dynamo may be said to have reached a high state of perfection, so that any radical improvement will have to be in developing a totally different type, rather than in greatly improving the present form.

A number of years ago the dynamo was already the most efficient transformer of power in use, being far superior in efficiency of conversion to the much older steam engine, boiler, turbine, or any of its class. It has long been so near to 100 per cent that improvements to increase this efficiency are necessarily of only small importance. The chief directions for improvements have therefore been to dimin-

ish their weight, cost, and attendance (self-regulation, fixed brushes, etc.), and to prevent the detrimental sparking. In all these directions important improvements were shown at the exhibition. The dynamo in its present form is a well-studied, well-developed, and highly efficient machine.

High and low tension.—Series lighting, so very largely used in the United States, appears to be almost unknown in France, and, judging from the exhibits from others countries, in Belgium and Switzerland also. The present system of running Jablochkoff lamps is the only exception of importance. High-tension, constant-current machines were therefore conspicuous by their almost total absence in the French, Belgian, and Swiss sections. There were several high-tension machines in the United States section, one in the English (Crompton), and one in the German (Steinlen).

With the exception of a few moderately high-tension series-wound machines for the transmission of power, the dynamos on the continent are mainly shunt or compound wound, for constant potential circuits of 60 or 110 volts, arc lights being usually run in derivation with incandescent.

Direction of development.—The tendency in France, as well as in other countries on the continent, seems to be to prefer to drive the larger dynamos directly from the engine by coupling the shafts, the belt being, to a great extent, confined to smaller machines. This naturally leads to slow-speed dynamos, and, consequently, to armatures of large diameter, which in turn, together with other considerations, leads to making the field multipolar. Many of the larger machines were therefore multipolar and with large armatures. In one prominent case (Siemens dynamo) the usual disposition of parts was completely reversed ; the Gramme armature formed the outside of the dynamo, the multiple field magnets being inclosed by the armature. This type is used in a number of the large central stations in Berlin.

Alternating-current dynamos.—Alternating-current dynamos were exhibited only by two or three exhibitors, the most important of which were those of the Thomson-Houston Company and that of Ferranti.

Field magnets.—With the exception of the tendency to make the field multipolar for large machines, there were but few important modifications shown.

The most radical change was in the Rechniewski machine, in which the whole-field magnets are laminated like the armature, resulting in diminishing the weight and gaining other advantages.

Another feature of interest in several machines used chiefly as motors was a small pair of auxiliary poles just beyond the main pole pieces, to fix sharply the position of the neutral line, in order to enable the brushes to remain fixed in position for all loads. It appears to give very satisfactory results.

In the multipolar frames, a form much used is one having radial magnets with a yoke piece encircling them all in common, as in the Oerlikon machine described below. It necessarily makes a rather large and heavy frame and has the disadvantage that, as the coils are generally slipped on from the inside, there are no pole-piece extensions, and there is necessarily a comparatively large amount of dead wire on the armature.

The so-called "type supérieur" is also very common for bipolar frames. It is a simple U-shaped magnet like the Edison but with the armature at the top instead of at the bottom, whence its name, which has no significance in the sense of the word "superiority" in English. This form has the disadvantage that there is a very considerable downward pull on the armature due to the combined action of the magnetic pull and the weight of the armature, two forces which act *against* each other in the Edison form.

In the proportions of the magnets the tendency is to make them short and thick. Ironclad magnet frames do not appear to be coming into use to any great extent.

Armatures.—In armatures there were a number of features of interest.

The only radical change was in the Desrosiers dynamo, which is of the disk type, without iron. It has some interesting features, but it is doubtful whether it will prove an important departure from the regular forms.

The large diameters of multipolar armatures, necessitated by slow speed of revolution, have given rise to an interesting development, though not novel, of an adaptation of the drum winding to cores of great diameter, without loss of dead wire at the ends. The core resembles that of a large Gramme ring, but has the windings only on the outside surface. A further description will be found below in the detailed description of the Thury dynamo.

In general, for large machines, makers have diminished the number of layers to a single one, for machines up to the usual 110 volts, and in some cases even higher volts, as in the 600-volt Oerlikon machine. This feature of a single layer has developed the so-called "built-up" armature, of which there were a number exhibited. In these the armature wires or bars are made separately and are then placed in position, one next to the other, and afterwards connected together, in distinction to being wound on in form of a wire. This, as a rule, makes a perfectly regular, symmetrical winding of very neat appearance, and having other advantages. The use of teeth or lugs on the armature, between the wires, seems to be meeting with more favor. As it gives rise to injurious Foucault currents in the pole pieces, it necessitates some modifications. This is accomplished in the Rechniewski dynamo by laminating the field, and in a number of other forms by magnetically shunting, as it were, the iron of the

core, by having a small amount of iron on the *outside* of the wires, as, for instance, by making the teeth meet on the outside, or covering the whole armature with a thin shield of iron. If the small loss of magnetism caused thereby accomplishes the object sought, as it appears to, it is a well-applied loss.

Brushes.—Brushes made of a fine copper gauze appear to be coming into use rapidly. Carbon brushes are also being used more frequently. Some improvements in brush holders also were shown, chiefly to prevent their heating.

Bearings and oiling.—Bearings are as a rule made large in diameter as well as in length. In the larger machines they are often supported on spherical pivots. The oil-cup feed is being replaced very rapidly by the ring feeder; so much so that the former method now forms the exception. In these ring feeders there is a reservoir of oil cast in the bearing below the shaft, and a very loosely fitting revolving ring rolling over the shaft carries the oil from the reservoir to the top surface of the shaft.

Exhibits by countries.—The exhibits of dynamos were pretty well divided among all of the principal countries who exhibited largely in the class of electricity. In numbers only, France excelled; but in importance and interest other countries were fully equal, especially Switzerland and United States.

Kilowatt.—In the accompanying detailed description of dynamos the term "kilowatt" will be used exclusively in referring to the output or power of a dynamo or motor. This term was adopted by the Electrical Congress of 1889 with a suggestion that it be adopted also by mechanical engineers to replace the arbitrary unit "horse power." It is a true unit of power, and is equal to 1,000 watts, as its name indicates; also to 1.3592 metric horse powers (or about four-thirds within 2 per cent), or 1.3406 English horse powers (or very nearly four-thirds within one-half per cent; 1 metric horse power equals 0.73575 kilowatts (or nearly three-fourths; 1 English horse power equals 0.74594 kilowatts (or very nearly three-fourths).

Comparative data.—It was intended to give here a number of the practical deductions of various important constants used in calculating and designing dynamos. but this had to be abandoned, as it was too difficult to obtain the desired information and to make the required measurements, as the exhibition administration forbid taking notes or making sketches, and whenever the information could be obtained from exhibitors it was generally with the understanding that it should not be published. This is to be regretted, as many valuable figures and constants could thereby have been deduced and useful deductions made. The writer is therefore limited here to a few very general deductions made from such information as could be obtained from published or public statements of the makers. The deductions are therefore necessarily crude, but will serve in a

general way for comparison as well as for their absolute values. The only useful deductions that could be made are the relative weights and the relative prices, both reduced to common units.

Watts per pound.—The first is reduced to the number of watts obtained per pound of dynamo complete, from which it be will be seen in the following table that this does not vary materially with the size, so that in general the statement can be made that the power of a dynamo increases in proportion to its weight. Most of the figures lie between 4 and 7 watts per pound; in a few of the heavier machines they are as low as 2.2 while in the very light Rechniewski machine it is as high as 11.5. With a very few exceptions the dynamos in the table are all low potential machines. In one high potential arc-light series machine (Crompton) the output is as high as 18.5 watts per pound, if the data are exact. These figures naturally depend greatly on the speed, which is therefore also given here. As the output in general would be proportional to the speed, a better and more independent figure of technical interest, showing the relative values of the different constructions, would be the watts per pound divided by the linear velocity of the moving wire of the armature, thereby eliminating the speed and giving due credit to the larger armatures; but this requires the size of the armature, which could not always be obtained.

Price per kilowatt.—The other deduction, the cost of the dynamo per unit of power, has been reduced to the cost price in dollars per kilowatt of power. This, naturally, varies with the size of the machine; but it will be noticed also that it varies very greatly with the manufacturers, and that in general it is, for the same size, about twice as great for the American machines as for the European; as the former may be taken as fair prices here, it shows the very great cost of dynamos in the United States as compared with those abroad. Even with a high duty it would be more economical to import dynamos from Europe. In cheapening the cost of dynamos we have therefore much to learn from abroad. The prices are all *list* prices, most of which are subject to a discount, especially those from the United States.

INCANDESCENT LIGHT AND POWER DYNAMOS.

Name.	Kilowatts (1,000 watts).	Volts.	Ampères.	Number of revolutions.	Watts per pound.	Price in dollars per kilowatt.
UNITED STATES.						
Edison	0.25	110	2.25	2,400	2.8	550
Do	0.5	100	5	2,400	4.2	320
Do	1.0	110	9	2,100	3.7	195
Do	2.5	125	20	1,900	4.5	120
Do	5.0	125	40	1,800	6.0	95
Do	7.5	125	60	1,700	6.9	87
Do	10.0	125	80	1,600	6.8	83
Do	15.0	125	120	1,500	7.0	78
Do	20.0	125	160	1,400	6.9	76
Do	25.0	125	200	1,300	7.0	75
Do	30.0	125	240	1,200	6.9	74
Do	40.0	125	320	1,000	5.9	71
Do	50.0	125	400	700	5.1	72
Do	80.2	140	575	650	4.9	69
Do	150.0	140	1,075	450	4.8	69
Thomson-Houston (motor type)	1.5	....	....	2,500	5.0	234
Do	5.0	....	....	1,800	7.1	120
Do	10.0	....	....	1,600	7.3	120
Do	30.0	....	....	1,170	6.0	90
Do	50.0	....	....	1,020	7.1	76
Do	62.0	500	....	900	6.2	81
FRANCE.						
Edison Company (French), "type superieur"	2.2	....	....	2,000	5.5	53
Do	6.6	....	....	1,400	4.5	38
Edison Company (French), Manchester type	17.6	....	....	1,000	4.7	33
Do	39.6	....	....	650	4.3	24
Rechniewski	14.3	110	130	1,200	11.5	....
Breguet (Old Gramme type)	1.0	110	9	1,500	4.1	97
Do	38.5	110	350	600	7.0	31
Desrozier	14.0	100	140	350	....	76
Do	16.5	110	150	800	....	42
Do	17.9	105	170	350	6.7	....
Do	192.0	120	1,600	300	....	23
Belfort	2.0	....	....	1,300	....	115
Do	11.0	....	....	1,000	....	57
Do	43.0	....	....	550	....	44
Gérard	0.28	35	8	....	....	138
Do	2.2	110	20	....	....	44
Do	3.3	110	30	....	....	41
Do	5.5	110	50	....	....	35
SWITZERLAND.						
Oerlikon, lighting	1.95	65	30	1,600	2.5	89
Do	13.0	65	200	600	3.3	44
Do	65.0	65	1,000	300	3.5	33
Oerlikon, power	3.7	....	....	1,250	2.2	78
Do	36.8	....	....	600	2.8	32
Do	221.0	....	....	240	3.3	28
Thury	27.5	....	....	450	6.2	....
Do	55.0	....	....	250	5.5	....

INCANDESCENT LIGHT AND POWER DYNAMOS—Continued.

Name.	Kilowatts (1,000 watts).	Volts.	Ampères.	Number of revolutions.	Watts per pound.	Price in dollars per kilowatt.
SWITZERLAND—continued.						
Thury	125.0	....	....	185	9.5	....
Zurich, lighting	13.2	110	120	800	3.9	....
Zurich, power	25.8	....	....	750	4.3	....
Winterthur	22.0	110	200	900	7.1	....
BELGIUM.						
Dulait	11.0	110	100	700	8.3	....
Do	35.8	110	325	650	7.3	....
Jaspar	10.5	70	150	875	....	42
Do	20.0	100	200	600	....	37
ENGLAND.						
Westminster	32.0	80	400	420	8.0	....
AUSTRIA.						
Ganz	1.7	110	15	1,400	3.1	....
Do	11.0	110	100	600	4.3	....
Do	44.0	110	400	375	4.5	....

ARC LIGHT DYNAMOS (FOR SERIES DISTRIBUTION).

Thomson-Houston (United States)	1.8	....	....	1,250	2.5	306
Do	8.4	....	....	900	2.4	262
Do	15.6	....	....	820	3.0	212
Do	22.8	....	....	820	3.8	175
Breguet (Old Gramme) (France)	14.3	1,100	13	800	4.3	51
Crompton (England)	32.5	1,300	25	....	18.5	24

ALTERNATING CURRENT DYNAMOS (EXCITER NOT INCLUDED).

Thomson-Houston (United States)	35.0	....	....	1,500	9.8	69
Do	70.0	....	....	1,070	8.5	67
Do	140.0	....	....	680	....	64
Zipernowsky (Austria)	10.0	1,000	10	....	6.5	....
Do	50.0	2,000	25	....	6.7	....
Do	160.0	5,000	32	....	6.6	....
Do	380.0	5,000	76	....	7.5	....

Jury tests.—The electrical jury of awards tested quite a number of the dynamos for efficiency and indirectly also for some other features, but the results obtained were for their use as jurors and not for publication. The efficiency tests were made by the usual electrical method of measuring the losses in the field, in the armature, and in stray power (friction, Foucault currents, etc.). The dynamo was run as a motor at its true speed, with separately excited field, and the electrical powers measured. This test, which is decidedly simpler and probably more accurate than a dynamometer test, serves

also to check some of the data furnished by the makers. The results obtained were probably within one-tenth to one-twentieth of their true value.

DETAILED DESCRIPTIONS.

As the number of different forms of dynamos exhibited is greater than the number of their exhibitors, no attempt has been made here to give a description of them all; nor was it thought necessary to give a complete description of any, as most of them have been described and illustrated in the technical journals.

The following descriptions are therefore limited to a short general summary of some of the more interesting though not always novel features. No attempt has been made at any classification, except into continuous and alternating current dynamos.

Awards.—The awards mentioned were not always for the dynamo alone, and are therefore omitted in some cases. In a number of cases the makers were represented on the jury and the exhibits were therefore not entitled to awards.

CONTINUOUS-CURRENT DYNAMOS.

Oerlikon.—One of the best exhibits of large and massive dynamos was that of the Oerlikon Co. (Swiss section, Grand Prize), the dynamos being designed by Mr. C. E. L. Brown. They were the only exhibitors who received the highest award, grand prize, chiefly for their dynamos. The only other two exhibitors of dynamos who received this high award were Thomson, and Edison, in the United States section, who, however, received it largely for their electrical work and researches in general.

There were three distinct types of dynamos in the Oerlikon exhibit: The first, a very large, massive, four-pole machine, for transmission of power; the second, for incandescent lighting; the third, a small, compact machine, chiefly for ship lighting. All three were coupled directly to their own engine.

Large Oerlikon.—The large one is shown in the adjoining illustration (Fig. 1) and is a good example of a large, massive, rigid machine of simple construction. It was one of the two largest dynamos at the Exhibition, the other being the large Edison dynamo of the same output, 150 kilowatts. It is a series-wound machine for the transmission of power, the magnets being wound with bands of copper 1 millimeter (0.04 inch) thick and as wide as the coil is long, about 12 inches, insulated by means of bands of paper of the same width. It is for about 250 horse power, at 600 volts and about 250 ampères.

The armature is a very neatly wound Gramme ring, about 40 inches in diameter, having a speed of 500 revolutions. This gives a velocity of the moving wire of 86 feet per second, which is very high, being almost double the usual velocity.

The field is very intense, being 51,000 effective lines of force per square inch, which is almost double the usual intensity. This is calculated from the electromotive force generated, the velocity of the wire, and the number of turns of wire on the armature, and therefore includes only the actual effective lines of force. This great velocity and intense field give the exceedingly high induction of 6.3 volts per foot of active wire, which is almost four times that in the usual machines, and is therefore probably the best obtained in a commercial

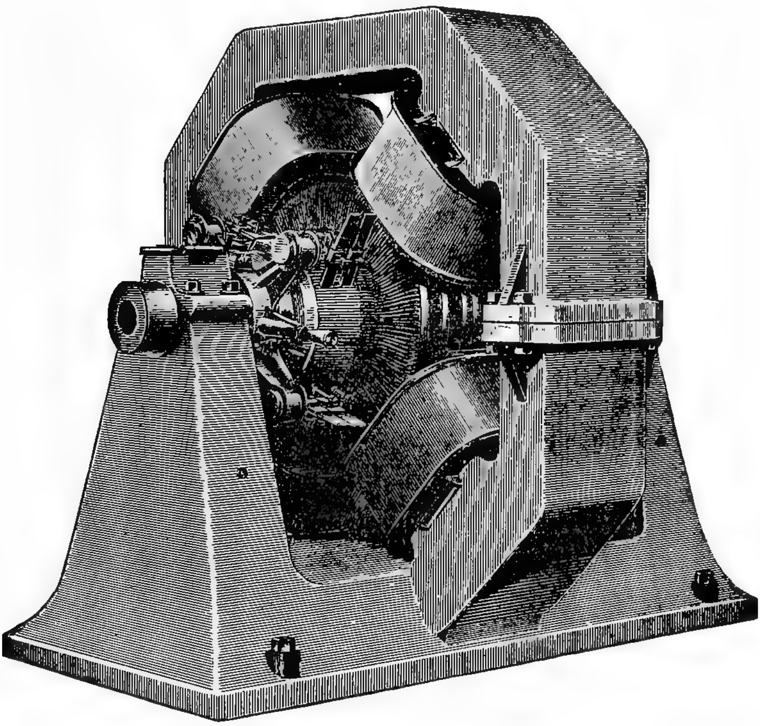

FIG. 1.—The Oerlikon Co.'s large dynamo

machine. The magnetic density in the armature core is about 78,500 lines per square inch, which is not very high. As the area of the pole pieces is the same as the cross section of the cores of the field magnets, the magnetic density in these cores, assuming no leakage, would be 51,000 lines per square inch.

From these figures it follows that there are 86 effective lines of force generated per ampere foot in the field magnet coils. The volts and amperes from which some of these deductions are made are probably a little too high, and, therefore also, the deductions which are based on the volts and ampères, but the difference is probably not very great.

The loss in the field is said to be 1,750 watts, from which it follows that there are about 20,300 effective lines of force generated per watt

in the field, which is also very high, being considerably higher than usual. This high efficiency of the field is due partially to the very low relative resistance of the coils, their nearness to the iron, the great mass of iron, and the fact that the magnets are partially ironclad.

The weight of the machine complete is 38,000 pounds, and the output being 150 kilowatts, gives about 4 watts per pound of dynamo. The same figure for the Edison machine exhibited, having the same output, but less speed, 450 revolutions, is 4.8 watts per pound, showing that the Oerlikon machine is heavier even at a greater speed.

The selling price is stated to be 18,000 francs, or $348, making $23.2 per kilowatt. These machines are used for the transmission of power, the single motor being similar but slightly smaller.

Medium Oerlikon.—The second type of machine exhibited by the Oerlikon Co. is of interest owing to its armature. The armature wires, instead of passing over the outside surface of the armature core, pass through circular holes through the core lengthwise just beneath the surface; the core, therefore, extends almost to the pole pieces. The wires consist of straight copper rods inserted into these holes and soldered at their projecting ends to the bars which lead back through the inside of the ring. It is in effect an armature with teeth which close over the wire on the outside, the wire being thereby inclosed entirely in iron.

The speed—360 revolutions—is comparatively low, the conductor velocity being only 38 feet per second, and as the field is not very intense the induction is therefore only 1.75 volts per foot. The weight being 13,500 pounds, and the output 110 volts and 370 ampères, or 40.7 kilowatts, the relative output is only 3 watts per pound. It is therefore not a light machine, but that is due chiefly to its having such low speed. It is used chiefly for lighting in multiple arc.

Small Oerlikon.—The small machines, used chiefly for ship-lighting, coupled direct to a small engine, has a peculiar field, though its form is not new. It has only two field coils, but has four poles, and the field is nearly ironclad. The frame is a low, flat, rectangle, inclosing the coils and armature. The middle of the long sides act as two poles, and the ends of the cores through the horizontal coils act as the other two. It is very compact and rigid; in fact, could hardly be more so. The mass of iron in the field is comparatively great.

Rechniewski.—One of the most interesting improvements, and probably the most valuable of all those shown, was in the Rechniewski dynamo, exhibited in the Russian section by the inventor (gold damel) and in the French section by the Société l'Eclairage Electrique (gold medal).

The improvement consists simply in making the field as well as

the armature of thin sheets of wrought iron, and having teeth on the armatures. The principle involved is that, for the same output, all parts of a dynamo may in general be made smaller and lighter if the field is made more intense. Now, the intensity of magnetism generated is dependent very much on the so-called "entrefer"—that is, the distance between the iron of the armature and that of the pole pieces, as this part of the magnetic circuit offers by far the greatest resistance. This magnetic resistance of the entrefer is very materially lessened by having teeth or lugs on the armature, extending out between the wires to nearly meet the pole pieces, a fact which was appreciated even in the early Pacinotti machines. But such teeth on the armature produce a very great and rapid periodic variation in the magnetism and thereby develop great and injurious Foucault currents in the pole pieces, so much so that they have in most machines been abandoned.

Numerous devices have been suggested and introduced to avoid this with more or less effect; Weston, for instance, cast his pole pieces with a few slots in them with the intention to diminish the Foucault currents; he also made the extremities of the pole pieces inclined, so as to avoid too sudden changes of the magnetism; Brown (see Oerlikon machine), made the teeth meet outside of the wire; Picou (see French Edison machine), made them so that they almost meet; Dobrowolsky connects the two pole pieces by thin iron bands, thereby losing some magnetism but apparently overcoming the effect of their heating; other makers do practically the same thing by covering the outside of the armature with iron wire, making a magnetic shield, as it were. The latter devices appear to be effectual; they are similar in effect to avoiding a spark in opening an electric circuit, by having a relatively high resistance as a shunt to the spark, thus avoiding to a great extent the injurious effects of the spark at a cost of some current.

Rechniewski, however, is more radical, and practically avoids the Foucault currents entirely by making the entire field of very thin sheets of iron, just as in armatures. He thereby has additional advantages: the iron used is of the very best and softest quality and therefore is better magnetically; the shape of the pieces is such that both armature and field disks are punched out of the same piece so as to have very little loss; furthermore, the whole field disk is in one piece so as to have no magnetic joints; as all parts are punched there is no further boring or shaping of the field; all that remains to be done is to bolt the plates all together, through punched holes, and to secure them to a base plate. The operation of punching is said to be quite cheap after the dies are once made, so much so that the whole cost of manufacture, for the same output of dynamo, is said to be considerably cheaper than that of the usual forms with solid wrought or cast iron fields.

There is no doubt that the machines exhibited are very small and light for their output, which shows that the iron and copper are more advantageously used. Any feature of a dynamo which enables a less quantity or cost of materials to be used in one part is a gain in a greater proportion than that of the weight saved. For instance, increasing the magnetic permeability of the iron of a core saves not only in the cross-section of iron but also in the copper of the coil, and thereby in the length of the core, etc.

The smaller Rechniewski machines are made in the ordinary horseshoe type of frame, like the Edison, but with the armature at the top; the large ones are made multipolar.

There being practically no Foucault currents, and the dimensions of both copper and iron parts being small, the dynamos can be built with a very high efficiency. A formula suggested by Professor Potier (see his paper read before the Electrical Congress, 1889), to determine the relative values or the relative economy of the frames of dynamos considered by themselves as a magnet, shows that the frame of this dynamo is far superior, magnetically, to any of those exhibited for which the figures could be obtained, the figures obtained (the lower ones being the better) being 7.4 as compared with values varying from 12 to 33 for other well-known machines. But this figure is of interest chiefly from a theoretical point of view, as it happens that the worst figure is that obtained from a machine which was apparently among the lightest and cheapest of those exhibited, giving over 18 watts per pound, and selling for about $24 per kilowatt of output.

The following data of one of the Rechniewski machines may be of interest: 110 volts; 130 ampères; 14.3 kilowatts; weight, 1,240 pounds; speed, 960 revolutions; linear velocity 31.5 feet per second; thickness of iron plates, 0.024 inch; 122 watts per pound of copper; 11.5 watts per pound of dynamo; electrical efficiency, 95 per cent; commercial, 92 per cent; total lines of force, 3,700,000; in armature core 135,000, in magnets 97,000, and in field 40,000, lines per square inch. It will be noticed from these that the dynamo is very light, giving double and even triple the number of watts per pound; also that the intensity of the magnetism is relatively very high.

A test made by the writer to measure the amount of magnetic leakage showed that, of the magnetism generated, only about 14 per cent did not go through the armature, the usual loss, in other machines, being about double this.

It was suggested that this machine could be used as an alternating-current motor just as it is, but it appears that it was not satisfactory, for some reason.

For a further description of the Rechniewski dynamo, with illustrations, see La Lumiere Electrique, February 16, 1889. See also

Bulletin de la Société Internationale des Electriciens, June, 1890, No. 69.

Desroziers.—The Desroziers dynamo exhibited by Breguet (French section, gold medal) attracted considerable attention, owing to its being totally different from the usual types.

It belongs to the class of disk machines, having no iron in the armature. In principle it resembles the Pacinotti disk dynamo of 1875, and also the disk dynamo devised by Edison a number of years ago and exhibited in the Electrical Exhibition of 1884 in Philadelphia as a historical model. It is therefore not new in principle, but has some novel features in its details.

The construction of the armature is necessarily very complicated, and it is a question whether it will compete very favorably with the much simpler, ordinary, well-built dynamos, as the few advantages gained seem hardly worth the extra complication; the cost of winding the armature must necessarily be quite great. In general appearance it resembles somewhat the old form of Siemens or the Ferranti-Thompson alternating-current machines, in which the armature is in the form of a thin, vertical disk revolving between the poles of horizontal magnets parallel to the shaft and arranged in a circle near the circumference of the disk. In the Desroziers machine there are six such magnets, each having wide pole pieces.

The armature is in principle somewhat like that in the well-known Ferranti-Thompson alternating-current machine, in so far that each wire passes out radially in the field between two opposite poles and returns radially through the next field of opposite polarity, thence out between the next, and so on; the currents induced in a wire are therefore in the same direction. Or it may be described as follows: Supposing the dynamo to have two sets of field magnets instead of six, the armature would, as far as the winding is concerned, be equivalent to a drum armature winding in which the cylindrical surface was developed into a flat disk perpendicular to the axis, the active straight portions of the wire being then radial instead of parallel to the axis. In one respect it differs, however, from multipolar machines; generally in such machines the sets of wires moving in a pair of fields are in multiple arc with all the other sets, but in this winding the coils in the different pairs of fields are in series, which has the advantage that should the fields be slightly different they will not induce different electromotive forces in coils which discharge their current in multiple arc.

Another device of interest, which is too complicated to be described here, is the method of so bending the wires outside of the field that they do not cross each other at right angles, but remain approximately parallel to each other in the same sense that the strands

of a slightly twisted cable are approximately parallel, though they change their relative positions. This arrangement, however, brings a very large mass of dead wire at the outside and the inside ends of the active wires.

A detailed description, with numerous illustrations, will be found in l'Electricien for 1888.

Thury.—The Thury dynamos exhibited by Cuénod, Sautter et Cie (Swiss section, gold medal), have a peculiar frame and armature differing from the usual types. The armature is of relatively large diameter; the six flat field magnets surround this armature in the form of a hexagonal frame, each side of which hexagon is one of the magnets and is almost tangential to the armature; in each of the six corners the magnets are joined to pole pieces. It is therefore a very compact form for such a large armature, but the composite construction of the frame does not commend itself, and it adds greatly to the labor in constructing them. They are, however, very well built, and belong to the better class of the large machines exhibited.

The armature is of a peculiar type, which appears to be meeting with favor and which has undoubted advantages, as it enables the ordinary drum windings to be used on armatures of large diameter without increasing the dead wire on the ends; it thereby enables great linear speed to be obtained and permits making the field multipolar. The general principle is that each armature coil is in the form of a rectangle, laid on the cylindrical surface of the core, nearly tangential instead of diametrical, as in the usual drum armature; the distance between the long sides being equal to the distance between the center of the pole pieces, and each coil being two coil spaces in advance of the preceding one, as usual. It is, in effect, an ordinary drum winding, if the two north pole pieces, for instance, on the two sides of a south pole piece are considered as the equivalent of the one diametrically opposite in the usual form. The core of such an armature is a ring like that for a Gramme armature, but it has no windings on the inside surface, and the windings all cross each other on the two ends.

Edison.—The Edison dynamos are too well known to require description here. The one large machine exhibited was of the largest size made and is their unit for central station lighting. It is a 2,500-lamp machine, for about 150 kilowatts; speed, 450 revolutions. In their present standard type the old form of multiple magnets have been replaced entirely by a single pair; their length has been reduced and the diameter increased; the length of the armatures has been reduced and the diameter increased. All the fifteen different sizes of this type of their machines appear to have the same relative dimensions. The outputs are said to be very nearly as the third power of the dimensions. These machines probably rank among the best of the large machines at the exhibition, and are good examples of a rigid, massive dynamo of simple construction.

Edison claims to have been, and doubtless was, the first to appreciate the importance of very large and powerful magnets in dynamos, a feature which has since been universally adopted. He has built machines weighing 27 tons, the armature alone weighing 6 tons, but these were soon abandoned. The one exhibited is the largest size made now, and gives 140 volts 1,075 ampères, weighing 31,000 pounds net; this is equal to 150 kilowatts, making 4.8 watts per pound, the speed being 450 revolutions; it is therefore a relatively heavy machine. The selling price is at the rate of $69 per kilowatt, which is exceeding high, being about double that of other European dynamos.

There was exhibited also a small high potential machine of 1,200 volts, of the same general appearance, but with a field magnet winding in sections. No satisfactory explanation of it could be obtained. It is for the municipal system of incandescent lamps in series.

French Edison Company's dynamos.—The French Edison Company build a number of different types, depending upon the purpose for which they are to be used. The ordinary type for lighting is in general like that of the American Edison Company. They still sometimes construct them with multiple parallel magnets, and sometimes with two sets of magnets and the armature in the middle, in which forms the magnets are consequently very short. The cores are generally wrought iron with cast-iron pole pieces. They make dynamos also of the Manchester type, but prefer the other. The leakage of lines of force in this Manchester type was found to be 33 per cent, as compared with 20 to 25 per cent in the ordinary Edison form. The Manchester type of frame is probably one of the poorest forms for economy of the magnetism generated.

French Edison Company's motors.—For motors from 2 to 8 horse power, to be used in constant potential circuits, they make a new and interesting form devised by Mr. R. V. Picou. The frame is a circular yoke-piece having four radial magnets on the inside, terminating at the armature. Two of these are large and two small; the two large ones are diametrically opposite to each other, are of opposite polarity, and are shunt wound; the two small ones are series wound, and are each of the same polarity as the large one *preceding* them in the direction of rotation of the motor. The object is to keep the neutral line in the same position for all different loads, in order that the brushes may remain fixed in position for all loads—a very important feature for motors whose loads vary continually, especially when they are in inaccessible places. This regulation of the neutral line is accomplished by these small series magnets by their drawing the neutral line forward as much as the increased current in the armature draws it backward, thereby keeping it in the same place.

The large magnets are wound as the short shunt—that is, as a shunt to the armature, and not to the whole machine, the object of which is that for increased load—that is, current—the potential at the shunt magnets falls, whereby the field becomes weaker and consequently the speed of the motor tends to become greater, which balances any tendency of the speed to fall with increased load.

The price of these motors is about at the rate of $22.50 per kilowatt, which is very cheap.

French Edison Company's small motors.—For very small motors they make a Gramme ring armature of peculiar form, in which the outside wires of the armature are almost entirely encircled by iron, the outside surface of the armature being entirely iron. The coils are wound into cylindrical longitudinal holes through the armature rings near their outside surface. The wire is wound into these holes by being passed through a narrow slot cut through from the outside to these holes, these slots being just wide enough to allow one wire to be passed through.

The whole is in effect equivalent to having teeth or lugs on the armature, which are so much wider at their outer end than at their roots that they almost meet. The advantage is that the space between the iron of the armature and that of the magnets is exceedingly small.

They claim to obtain more watts per pound by this arrangement. An 8-ampère motor at 110 volts weighs 75 kilograms, which makes 5.3 watts per pound of motor. They are said to require much more compounding than other forms.

Crompton series dynamos.—The dynamos of Crompton & Co. (British section, gold medal) were the only ones exhibited in the British section. Their arc-light machines are probably among the best known in Great Britain, and are too well known to require description here. They were among the very few series-wound dynamos exhibited for high-tension constant currents.

The chief claim is for lightness and for maintaining a practically constant current, which is not materially affected by slight changes of speed and load. This latter is accomplished by increasing considerably the cross-section of the iron of the armature as compared to that of the magnets, the proportion being 1.0 to 0.98, while that in the usual constant potential machines is said to be 1.0 to 1.4 and 1.8. The magnets, being series-wound, are therefore normally supersaturated, while the armature is not. A slight increase in current, due to diminution of external resistance or to slight augmentation of speed, will, therefore, not affect the magnets materially, but will increase the counter-magnetism of the armature, which will shift its neutral line in the direction of rotation and thereby diminish the electromotive force of the machine, thus effecting an approximate regulation of the constant current.

In the characteristic of such a series machine, giving the relation between the volts and the ampères, the point of normal current, 25 ampères, would be slightly beyond the point of maximum potential; that is, it would be just beyond the beginning of descent of such curve. The maker claims that in other machines of this nature, namely, the Brush and the Thomson-Houston, the armature is also saturated, which therefore diminishes the efficiency of the machines and increases their weight and cost. In one of his machines, giving 1,300 volts and 25 ampères, or 32.5 kilowatts, the loss in the armature is given as 850 watts and that in the magnets 870 watts, giving an electrical efficiency of 97 per cent, while the commercial efficiency is stated to be 94 per cent. The weight of the machine is 1,760 pounds, making, therefore, 18.5 watts per pound of machine.

The selling price is $770, making about $24 per kilowatt.

In its construction it differs from almost all other machines exhibited in that the magnets are wound with wire of square cross-section instead of round, as usual, whereby the volume and weight of the coils are diminished. He claims to have been the first who adopted a radial depth of one-fifth of the diameter for the cross-section of the Gramme ring, and which, he claims, was an important improvement which all other makers have since adopted.

An illustration of these machines, though not accompanied by a description, will be found in the Electrical Engineer (London), August 2, 1889.

Crompton compound dynamos.—The same maker also claims to have been the first to develop and adopt the compound winding for constant potential machines in 1882.

A novel device used in his heavy-current machines is that, instead of using solid bars of copper, there are four bars of square cross-section, which are twisted through a half-turn about at the middle, the object of which is to prevent the generation of Foucalt currents in the bar itself, which are apt to exist when the bars are very thick. In the large Edison machines a similar principle is adopted, probably for the same purpose.

Belfort.—The dynamo known as the Belfort dynamo, exhibited by the Sociétè Alsacienne de Constructions Mecaniques (French section, gold medal), is like an Edison machine turned upside down, the armature being at the top. The strong magnetic downward pull on the armature, which is the great objection to this form, is claimed to be overcome by extending the iron cores to the extreme end of the pole pieces instead of tapering them off as usual, but it is probably only a partial remedy for this evil. The cores are of round wrought iron, while the yoke and pole pieces are cast and fitted to this round core, thus facilitating the winding and removal of this coil if necessary.

An accessory of interest is a brass spun cap secured to the pole

pieces and covering the end of the armature to the commutator. This adds greatly to the appearance and protects that end of the armature from the metallic dust of the commutator.

Another feature is that the commutator is made of steel bars secured only at the armature end, the inside of the commutator being quite open and the insulation between the strips being air. It can be readily cleaned and probably lasts much longer than one made of copper as usual.

Siemens.—Another dynamo exhibited by the same company and called the Siemens dynamo is interesting on account of the very odd form, though it is very doubtful whether the few advantages gained justify the increase in the complication.

It consists of an enormous Gramme ring about 6 or 7 feet in diameter and supported at one end, leaving both the inside and outside free from obstructions; the radial magnets, of which there are a number, are on the inside only; the windings on the outside of the Gramme ring are made of bars of bare copper, which at the same time constitute the commutator, on which as many sets of brushes slide as there are magnet poles.

The outside appearance of the machine therefore resembles a huge copper fly-wheel on which the brushes slide. It is in fact merely a multipolar Gramme machine with the magnets on the inside instead of the outside, the windings on the outside of the ring itself constituting the commutator or collector.

The chief advantage is that great circumferential speed is thereby attained at slow speed of revolution. The great amount of copper required on the ring and the great speed at the brushes are attending disadvantages, as is also the complicated link, gear, and lever mechanism for holding the numerous sets of brushes and for enabling them to be moved together and lifted off simultaneously.

This is the type of machine made by Siemens in Berlin and is used largely in some of the central stations at present being erected in that city. In the latter the dynamos are so large that they must be built, to a great extent, in place in the stations themselves. The armature in these acts as the fly wheel of the engine, to which it is coupled directly.

Thomson-Houston arc dynamo.—The Thomson-Houston (United States section) arc-light machine is apparently the same as it has been for a number of years. It appears to be commercially a very good arc-light machine, in spite of the apparently irrational construction of the field.

Thomson-Houston power dynamo.—Their dynamo for power and motor work is of the same type as the Edison, only that it has the armature at the top instead of at the bottom. One of these was placed side by side with one of the older forms of the same output,

showing the great improvement in favor of the newer form in size, construction, and appearance.

Thomson-Houston miniature dynamo.—In the personal exhibit of Prof. Thomson was a miniature dynamo of some interest, as it is probably the smallest ever built. The object was to study the self-exciting property for a small shunt machine. Its armature was about 1 inch in diameter and 1 inch long, making 8,000 revolutions and giving 2½ volts and 3 ampères; its weight was 2.2 pounds, which corresponds to 3.4 watts per pound; the two largest machines at the exhibition, the Oerlikon and the Edison, each for 150 kilowatts, gave 4 and 4.8 watts per pound, respectively; the output of this little dynamo is therefore nearly the same as that of large ones. Small as it was it excites itself as a shunt machine, which is said to be quite remarkable. It is said to have been built with as nearly as possible the same relative proportions as their largest machine for the transmission of power.

Miot.—The distinctive feature of the Miot dynamo exhibited by Mégy, Echeverria & Bazan (French section, silver medal), is that there is considerable space between the poles pieces, it being greater than that part of the armature covered by the pole pieces; the coils on the Gramme armature, which are thereby rendered inactive, are short circuited by two brushes connected together, taking the place of the usual single brush for each pole. It is claimed that thereby the sparking is reduced, because the current is not reversed in the separate coils as abruptly as usual, which is one of the chief causes of sparking.

This idea is not new, however. It was used here many years ago. It is a question whether the increased amount of wire and the increased size of the whole machine justify this advantage.

Another feature which appears to be meeting with favor is that, besides the usual field-magnet poles, there is a small series-wound magnet resembling an additional field magnet, its pole pieces being placed a short distance beyond those of the large magnets and having opposite polarity to these. The intention is that the neutral point on the armature should thereby be fixed very definitely in its position for all different loads, so that the brushes do not need to be moved when the load changes.

This machine was one of those used to operate one of the two traveling cranes used in Machinery Hall.

Deprez.—The Deprez dynamo exhibited by the Société Anonyme pour la Transmission de la Force par l'Électricité (French section), is characterized by its having two Gramme armatures on the same shaft, with the pulley in the middle, between the two magnets. The field magnets are composed of two horizontal magnets parallel to the shaft, each one terminating at each end in a pole piece; or it

might be said that the second armature was put in that part of the field which is usually a yoke piece.

By this arrangement each line of force is cut four times by the armature wires, instead of twice, as usual. It is claimed that thereby a greater output is obtained; it is a question, however, whether the additional complication is worth this possible slight gain. There is another claim made that a higher potential may be more readily obtained by two armatures in series than by one, on account of the current breaking through. This would be the case in cylinder armatures, but not in Gramme, as the danger in these is not between the wires, but between the wires and the frame. Unless the two frames of the armatures were insulated from each other this claim is hardly substantiated. It has the great disadvantage of a very long shaft and that the belt can not be removed without cutting it.

Gramme.—The chief features of the Gramme dynamos exhibited by the Société Gramme and the Companie Électrique are their simplicity and rigidity. The frames are all of the "type superieur," by which is meant a simple horseshoe magnet like the Edison, but having the armature at the top instead of at the bottom. They are neatly made and exceedingly simple in construction.

One of the most interesting portions of the exhibit of the Société Gramme was the historical exhibit of the Gramme dynamos, showing the different forms which have been built, from some of the very earliest, and representing the development of the present form.

Sautter-Lemonnier.—The dynamos exhibited by Sautter-Lemonnier (French section) are chiefly of the Manchester type with Gramme ring, for use principally with their search-light projectors and lighthouse lights, for which they have a world-wide reputation.

They exhibited also a very small dynamo coupled directly to a turbine steam-engine of exceedingly high speed, for use chiefly on ships. The whole engine and dynamo are exceedingly small and run very smoothly; notwithstanding the comparatively great consumption of steam, they appear to be meeting with favor for special cases, for which they have undoubted advantages, as they are portable and require practically no foundation. The following figures of these may be of interest. There are eight sizes built: for No. 2, next to the smallest, some of the figures are as follows: 70 volts 30 ampères, or 2.1 kilowatts; 8,500 revolutions; linear speed, 138 feet per second; induction, 0.85 volts per foot of total length of wire, which may be equal to about 1.5 volts per foot of active wire; this is not particularly high, considering the exceedingly high linear velocity, which is about three times the usual velocity in small dynamos.

The total weight of engine and dynamo together is only 550 pounds, giving the exceedingly high figure of 3.8 watts per pound of engine and dynamo together, which is better than that obtained in some dynamos alone without engine. The electrical efficiency is given as 88

per cent and the commercial 60 per cent. It is stated to require 180 to 200 pounds of steam per electrical horse-power; for the larger sizes about half this consumption. Size No. 8 is made for 400 ampères and 80 volts, the linear velocity in which is almost 250 feet per second, or almost 3 miles a minute!

Breguet.—The firm of Breguet (French section) exhibited quite a number of different varieties of dynamos, designed for different purposes, chiefly for ship lighting. With the exception of the Desroziers machine, described above, their dynamos have apparently no features differing materially from the usual forms. They use the Gramme ring armature, with frames of various well-known types. One of their types is the old original Gramme form of frame, but it appears that this is used only for small outputs. One of their specialties seems to be small vertical high-speed engines of compact form, coupled directly with the dynamo, chiefly for ship lighting, and adopted by the French naval department.

Pieper.—In the Pieper dynamo (Belgian section, gold medal) the armature core is made of iron wire instead of plates, as in the older Gramme rings. It is rusted and then coated with shellac before it is wound. The form of core is like that of a Gramme ring, but the windings are only on the outside surface and are on the drum system, the machine having four radial poles.

The armature wire is made of bare copper bars of rectangular section, with air insulation, which acts also as a ventilator, as the core in this case can not be ventilated as in those made of disks. These bars are connected at their ends by copper strips bent somewhat like a bracket, thus: ⏞, the middle of which is connected to the commutator. These pieces are all the same size and shape, and cross one another in such a way as to make very short and quite regular and symmetrical "heads" to the armature. It greatly simplifies the winding and makes it almost impossible to make an error in the winding or connections. The objection is that these end pieces must all be soldered to the bars, which presents difficulties, as "crosses" are apt to occur at these points, which burn out the armature.

Zurich.—The Zurich machine exhibited by the Société des Téléphones de Zurich (Swiss section, silver medal), and shown in the adjoining illustration (Fig. 2), was, besides the Lahmeyer, the only dynamo constructed on the "ironclad" principle, which appears to have been invented, as applied to bipolar machines, a few years ago almost simultaneously by three different inventors, Wenstrom, Hering, and Lahmeyer, in Sweden, United States, and Germany, respectively.

In this form the relative position of the coil and its iron core are reversed, the iron surrounding the coil; this is really the most rational form for a magnet, as all the lines of force have a complete

circuit of iron, instead of partly of air, which is almost the highest resisting body for lines of force.

There is no external magnetism in such machines, and they are for this reason especially applicable for places such as on ships or on tram cars, where such external magnetism is very objectionable—in the former on account of the compass and in the latter on account of the effect on the watches of passengers.

They are at best, however, heavy, but have the advantage of being very compact and solid.

Their external appearance, as will be seen from the illustration, is that of an iron box, nothing being visible except the ends of the bearings and the commutator. The armature is therefore well protected and at the same time readily accessible.

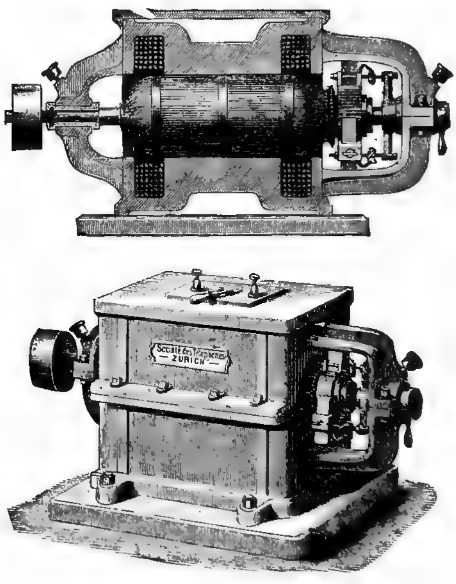

FIG. 2.—The Zurich dynamo.

Jaspar.—The Jaspar machine (Belgian section, gold medal) has changed very little from the original type. Its characteristic feature is a Gramme armature of great length as compared to its diameter, resembling in its proportions a drum armature. It is probably the only Gramme armature made with such proportions. There is only one layer on the armature, and the number of coils is comparatively great. The chief claim for it is cheapness. For greater outputs he uses an octagonal frame in one piece, having four radial magnets, whose ends form the pole pieces.

A characteristic feature is a set of three large, bare, copper rings, fixed to the frame near the brushes and concentric with the armature. These serve as universal connectors with which all connections be-

tween the four magnets, the eight pairs of brushes, and the machine terminals are made.

Dulait.—The Dulait dynamo, exhibited by the Société Anonyme Électricité et Hydraulique (Belgian section, gold medal), is in appearance almost identical with the Victoria-Brush or the Schuckert-Mordey machine. It has four poles and is compound wound. The advantage of this type of machines is the great diameter of the armature, and the consequent great inductor speed with relatively slow speed of revolution. It has the disadvantage of this type that it is very difficult to take out the armature should anything happen to it.

Henrion.—The Henrion dynamo (French section, gold medal), shown in the adjoining illustration (Fig. 3), is a slight modification of the well known Schuckert type. The four horizontal magnets,

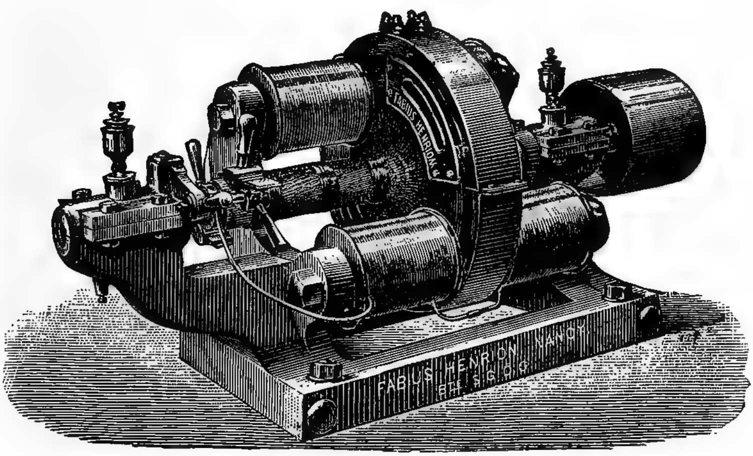

FIG. 3.—Henrion dynamo.

instead of being in a vertical plane, as in the Schuckert form, are in an inclined plane, so as to enable the armature with its shaft to be lifted out quite readily, the inability to do this being the chief fault of the Schuckert form. This dynamo was the only French one exhibited for high-tension constant current for arc lamps in series.

Sperry.—In the Sperry dynamo (United States section, silver medal) the Gramme armature is held at one of its ends, leaving the inside free for additional pole pieces. The pole pieces are split somewhat like a tuning fork, in the slot of which the armature moves, so that almost the whole length of the armature wire passes through the field, instead of only the outside portion as is usual. By this means it is claimed that the induction is increased. This may be so to some extent, as the resistance of the magnetic circuit is thereby diminished. A good illustration of the machine will be found in the Electrical World, June 15, 1889.

Perret.—In the Perret motor for very small powers (United States section, silver medal), the field magnets of the horseshoe type were made of links of punched wrought iron, jointed together by pins, so as to form two joints at the end of the yoke piece. The chief object of this appears to be that the whole magnet may be straightened out to form a straight bar, which can be put into the lathe to wind the coils on to it. It would seem, however, that this saves merely the work of winding the coils on spools, which are then slipped over the cores. The drum armatures, of only 2 inches in diameter, having 11 coils, and wound for 110 volts, are exceedingly neat examples of armature winding.

Postel-Vinay.—In the Postel-Vinay dynamo (French section) the magnets are made of cast steel in preference to cast iron, as it is claimed that the former has better magnetic qualities than the latter.

Gérard.—The Gérard machine (French section) is of some interest, owing to its great simplicity and cheapness. It has four radial magnets like many others, but the armature consists simply of four similar magnets, only smaller, and joined at the shaft forming a sort of double Siemens H armature; the alternating current produced is redressed at the four-part commutator. They are chiefly for small outputs.

Contades.—In the Gramme armature of the Contades dynamo (French section, honorable mention) the coils are wound separately on links which are afterwards secured by pins, forming the round Gramme ring; but its application was limited to quite small machines.

ALTERNATING-CURRENT DYNAMOS.

General.—The exhibits of alternating-current dynamos were very few, and of these there were only a very few of interest. Most of those exhibited were of the older well-known types. It is to be regretted that there were so few exhibits, as the subject is of much more importance than would appear from the few exhibits.

Thomson-Houston.—Among the most interesting features in this branch were some of the novel points in the Thomson-Houston (United States section) alternating-current machines. One of these is compound wound or "composite," as the makers term it, in order to maintain a constant potential. The connections are shown in the adjoining cut, Fig. 4. The machine has ten radial field magnets, which are wound with a coarse and a fine winding. The armature coils are wound flat on the cylindrical surface of the armature.

The fine-wire field coils, corresponding to the shunt coils of an ordinary compound-wound machine, are excited by a separate machine as shown; the coarse-wire coils are connected in the main circuit as series coils. This is accomplished by the following device: One end of the armature coils is connected directly to line by the sliding col-

lector as shown; the other end leads to a commutator or redresser having numerous insulated bars, the alternate ones of which are connected together, whereby the alternating current is redressed, passes, as shown, around the magnets, and back to the other brush of this commutator, where it is again commuted into an alternating-

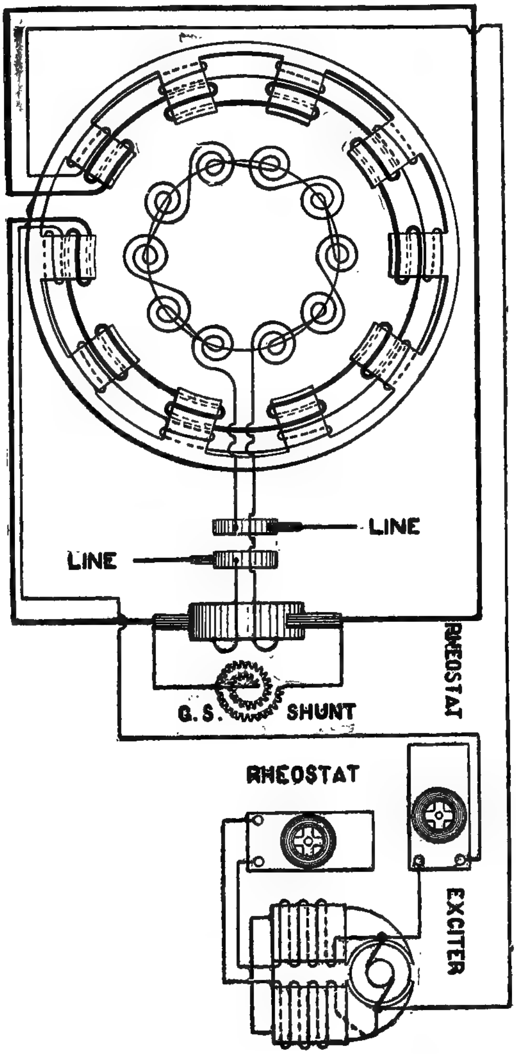

Fig. 4.—Diagram of the Thomson-Houston alternating-current dynamo.

current, and thence it passes to the line through the other collecting ring; by this means the current is redressed in that portion of its circuit only which passes around the field magnets.

A shunt coil of German silver, having some self-induction, is connected to the redressing brushes as shown; by adjusting this the

proportion of the series excitation, and therefore the characteristic, may be varied for each particular installation. This coil also acts to diminish the sparking.

An interesting feature of this is that notwithstanding the great current which is redressed there is almost absolutely no sparking at the redressing commutator. This is partly due to the fact that the difference of potential at this redresser is very small. In another machine this same redresser is used to make the machine self-exciting. The current from a few separate and independent coils on the armature is thus redressed and is used to excite the field.

Thomson alternating-current motors.—In the personal exhibit of Prof. Elihu Thomson were shown some experimental motors of interest on account of their radical difference from all others in their action. They have been described in the journals in connection with his other recent researches, and are therefore probably well known to those particularly interested.

The principle is briefly as follows: When running normally the armature is short-circuited and has no connection with the circuit; the current in the armature coils is generated by the induction from the field coils as in a transformer, but owing to the retarding effect of this induction the repulsions between the armature and the field coils, or secondary and primary as they may be called in this case, are greater than the attractions, and there is therefore a continual repulsion between the two, which rotates the armature.

In order to arrive at the conditions for producing this induction at the right moment the motor must first be started. This is done by an auxiliary commutator and brushes, by means of which the motor is first connected as an ordinary continuous-current motor, even though the current is alternating. As soon as the proper speed is reached, which is determined by the unison of the two musical notes heard, or by an automatic governor, the armature is disconnected from the main circuit and is short-circuited.

This motor is only an experimental one; in the present form it could not be used in practice. One great and fatal objection is that if the speed is reduced even only slightly by overloading there will no longer be the required synchronism and the motor will stop completely.

Ferranti.—There was a Ferranti machine exhibited by the Société l'Éclairage Electrique, but it presents few points of novelty except in details. One of its features was that half of the machine could readily be slid off to one side to enable it to be cleaned and dusted around the internal parts. This cleaning had to be done once every day. The oiling was continuous by means of pipes from an elevated reservoir into which the drains were pumped continuously. The machine was for 175 horse power, giving 2,400 volts and making 500 revolutions. There were 20 poles, and the mean radius of the armature was about 43 inches.

Heissler.—The peculiarities of the Heissler alternating-current machine (United States section, gold medal) are that the field magnets rotate like in the Gramme alternating-current machine, and the coils in which current is induced are fixed and are connected in series in two groups whose coils alternate. By this alternation and division into two groups it is claimed that better induction is obtained than if they were all connected together as one. These two groups feed two different and independent circuits.

Maiche.—The small alternating-current magneto exhibited by Louis Maiche (French section) was interesting as an oddity, as it has neither brushes, collector, nor moving wire. It is not the only one having these features, as the Klemenko (Russian) dynamo exhibited as a commercial machine in Vienna Exhibition in 1883 was of a similar nature, though the construction was different.

The coil in which the current is induced is fixed to the field magnets; the revolving armature consists of a piece of iron having projections on its surface which come close to the field-magnet poles and into which the lines of force pass. These projections are so spaced that the lines are drawn alternately into one and then into the other, and in thus changing their position they cut the the coil, thereby inducing a current. The relative output is probably quite small.

The brushes for an alternating-current machine present so few objections that it does not seem advisable to get rid of them at the cost of greatly increasing the size of the machine.

DYNAMO ACCESSORIES.

Gauze brushes.—In a very large proportion of the dynamos exhibited the brushes used were made of wire gauze in place of the usual foil. They appear to be very satisfactory and are coming into use very largely. They are made of a very finely woven-wire netting or gauze of soft copper, somewhat like that used in paper-making. They consist of a number of layers of this gauze over one another and bound together by a wrapping or covering of the same material. They are soft and pliable, and do not "sing" or "scream" like the hard, elastic foil brushes. They can very readily be made for any current capacity by the attendant of a dynamo himself. None of them were noticed on any American dynamos.

Carbon brushes.—Another style of brush which is coming into use largely, but which was noticed only on the motors for cars in the United States section, is simply a slab of carbon, held so as to be almost or quite perpendicular to the surface of the comutator. The chief object of their application in this case was probably that the motor can turn in any direction, and that any wear will not change their position, as in the tangential brush. The objection to them appears to be that they are apt to "scream" or "cry," but it is claimed that if the commutator is quite smooth they will move

quietly and will not wear the commutator unevenly, so as to cause "screaming." The idea is not new, but it does not appear to have come into use until quite recently.

Brush accessories.—In one of the dynamos the copper brushes were split at the holder end, so as to leave room for the clamping bolt. This device greatly simplifies the brush-holders. The well-known device of shunting the brush holder, by a flexible wire attached to the brush clamp and to the pin on which the holder turns, is being used by quite a number of makers. The object is to "take the heat out of the holder," or, in other words, to reduce the resistance, which sometimes becomes very high, at the sliding contact of the pin on which the holder turns, and which sometimes diverts the current so that it passes through the springs, thereby heating them and drawing their temper. Another old device, which is being adopted largely, is a fixed guide attached to the holder to mark the exact length to which the brushes should project from their holder. Another device for the same object, though not as good, is to mark two diametrically opposite points on the commutator, by which the brushes are adjusted before starting.

Brush-holders.—In the Alioth dynamo there was a very ingenious brush-holder of simple and rational construction. Besides its simplicity and cheapness, it has the advantage of avoiding entirely all sliding contact at the pivot, which contact is so often the cause of trouble. It consists of a straight flat spring, composed of a large number of thin sheets of spring copper, resembling the ordinary foil brushes. One end of this is securely clamped to the usual rod on the rocker; the other end is soldered to a clamp which holds the brush proper. There is therefore no loose or sliding contact in any part, while at the same time the brush is held with all necessary elasticity. The brush itself is almost perpendicular to this flat spring, the object being that when the pressure is being adjusted at the fixed end of the spring the end of the brush remains in the same position on the commutator. Similar brush-holders, differing only in detail, were noticed on the Belfort and on the Henrion dynamos.

Driving-gear.—Some of the Gramme machines exhibited were driven by friction pulleys of paper disks clamped together. There was one on each end of the shaft, and they rolled directly on the surface of two large cast-iron pulleys. The pulleys had a 9-inch face, and each transmitted about 8 horse power at a surface speed of 45 feet per second. They were only slightly warm after running. Breguet exhibited a Raffard coupling for connecting the shaft of the dynamo direct to that of the engine for direct driving. It is flexible and elastic, the transmission taking place through the medium of rubber bands.

Another coupling for direct driving was exhibited by Weibel, Briquet et Cie (Swiss section), the object of which was to double the

speed of the shaft which was driven. This was accomplished by means of a pecular link and crank movement contained in the coupling, a description of which will be found in "Engineer," London, July 19, 1889, p. 48.

Dynamometer.—Some of the dynamos and motors of Deprez were arranged to measure and record the work which they were consuming. The field magnets are supported and balanced so as to be able to turn easily through a small angle around the shaft as a center, the turning force being the magnetic force at the surface of the armature. This deflection is made to move a small friction roller from the center toward the circumference of a revolving disk perpendicular to it. This disk is revolved by the dynamo shaft and drives the friction roller with a greater or less velocity, according as the latter has been moved a greater or less distance from the center; as that displacement is proportional to the deflection of the magnets, the number of revolutions of this roller recorded on a counter will be proportional to the product of the number of revolutions of the dynamo and the force at the periphery of the armature, and will therefore measure the work.

References.—For regulators and other accessories to systems, see "accessories."

TRANSFORMERS.

General.—The system of distributing electricity by means of high-tension alternating currents, and converting these into quantity currents by induction in transformers, was suggested and even patented a number of years ago, but it was not developed into a practical and successful commercial system until within the last few years, and it may therefore be classed among the more recent developments in the distribution of electricity. It was exhibited the first time at the Vienna Electrical Exhibition in 1883, by Gaulard & Gibbs, but although it attracted much attention there the system does not seem to have given very satisfactory results until a number of years later, when it was developed independently in Austria, the United States, and England, into a successful commercial system, and it may now be classed among the most important of the recent developments. The allied system of transforming continuous currents, though older, does not appear to have developed into an important system.

Exhibits.—There were so few exhibits of transformers that it may be said that in this branch the exhibition did not represent the present state of the art. The Thomson-Houston multiple arc distribution and the Jablochkoff candle series distribution were the only two commercial systems exhibited in operation. It is to be regretted that this should have been the case, as it would have added greatly to the interests of the exhibition to have had this new system more widely represented.

Mr. Louis Maiche, an exhibitor in the French section, claims that the principle of this system of transmitting electricity of high tension and converting it by means of transformers into low tension at the place of consumption, was patented by him as early as September 15, 1880, and that his patent was sustained by a decision in the United States patent office.

The Thomson compensating system, exhibited by the Thomson-Houston Company, although somewhat similar in its object and apparatus, is not properly a transformer system, and is therefore described under another heading. (See "Systems of transmission and distribution.")

As usual with newly developed systems, it was not possible to obtain from the exhibitors figures and data regarding transformers. The following detailed descriptions must therefore be limited to a mere mention of the exhibits.

Alternating current transformer.—The Thomson-Houston Company had a few transformers in daily use. They were made of a pile of sheet iron plates having retangular holes for the coil and an opening through which the coil was introduced; this opening was then closed by a tightly fitting wedge-shaped plug, also laminated. There were two styles of plates exhibited, one formed like the letter H and the other like the letter E. In the first the coil must be wound on to the pile of plates and can not be removed without unwinding. The plugs are introduced at the top and bottom. In the second form the coil is wound separately and then placed into the pile of plates from the side. This is the new form which seems to be preferred. The coil can readily be removed for inspection or repairing. In both forms the magnetic circuit is completely of iron, and each line of force traverses two joints in the iron. No data regarding the dimensions, weights, or capacities could be obtained. The same forms of plates were used for their self-induction or compensating coils in their compensating system, which see under that heading. (See "Systems").

Constant alternating current transformer.—In the personal exhibit of Prof. Thomson was shown an interesting transformer in which the secondary circuit would generate an alternating current of constant quantity—that is, of a fixed number of amperes—for variable resistances in the external circuit, the primary circuit being connected to the usual constant potential mains. Usually the secondary current has a constant potential instead of a constant current strength. The principle of this transformer is that a portion of the magnetic circuit is an air space, which acts as a great magnetic resistance. This gives the transformer a characteristic curve for volts and amperes in the secondary, which is practically a straight line between certain limits, between which the current will, therefore, not vary very much for different external resistances. It

was shown in operation with a constant alternating current arc lamp of about 50 volts in the secondary, the primary being connected to a 1,000-volt multiple arc circuit.

Jablochkoff candle transformers.—In the system of distribution used at present for the Jablochkoff candles, there is a transformer with each lamp containing a number of candles. These transformers are all in series. The several candles in each lamp are all in multiple arc on the secondary circuit of a transformer, but their resistance when not lit is so very high that practically all the current passes through the one which is burning; when this is consumed it cuts itself out by melting a fuse; the potential in the secondary circuit then increases sufficiently to light one of the remaining ones, and so on until all are consumed.

Continuous current transformers.—The apparatus exhibited by the Popp Company (French section, silver medal), called an "onduleur" (undulator), is for enabling an ordinary transformer to be used on a continuous-current series circuit. It consists essentially of a commutator, which rapidly reverses the high-tension continuous current, making it an alternating current, which then passes through any convenient transformer, where it is converted into one of low tension.

The main feature is that the current is changed in direction very gradually; hence the name "undulator." The actual commutation takes place at the moment when the apparatus is short-circuited. This is accomplished by a rapidly revolving cylindrical commutator, which makes the following series of connections: The line current passes through the transformer and a resistance in multiple arc with it; this resistance is arranged in a succession of steps, in series, each connected by brushes to this commutator; the commutator, in revolving, brings one after the other of these resistances into circuit, and finally opens that branch, when the whole current goes through the transformer; it then puts them into circuit again and reduces their number, step by step, until this resistance, and therefore also the transformer, are short-circuited, at which moment the commutator reverses the current.

This series of connections is repeated in very rapid succession. It will be seen that the alternating current is thereby made to vary gradually and the sparking is very greatly reduced. There are always two such commutators, with their transformers, at one station, the two commutators being connected to the same revolving shaft, but in opposite phases. The object of this is that the two waves of the primary current balance each other, so as not to affect the rest of the main line or the dynamo. The commutator, which must necessarily revolve very rapidly, was turned by a small compressed-air motor, supplied from the compressed-air mains of this company, which are laid by them for general power distribution in parts of the city of Paris. The economy of this system of trans-

formers can not be very great, and its application is necessarily limited.

The Gramme Company exhibited a continuous-current transformer in the form of a dynamo with a double winding on its armature, one part of which was for driving it as a motor from the high-tension current and the other was the generator for the low-tension current. It was said to be exhibited only as a historical model, the device being comparatively old and little used.

ARC LAMPS.

Historical.—In the Centennial Exhibition of 1876, held in Philadelphia, there were among the exhibits from France, in Machinery Hall, a few arc lamps run from dynamos. They were exhibited not as a curiosity, but as a commercial system of lighting. This was the first exhibit of the commercial arc lamp at a large international exhibition, and it was probably the first introduction into America of the arc light as a means of subdivided light. Although individual arc lights may have existed here before that time, yet they were more in the nature of experiments, and can not be said to have been commercial lamps.

The arc lamp had been introduced in France in the winter of 1874 and 1875 in permanent installations for lighting shops and factories. Prior to this the only use seems to have been for single large lights for light-houses and similar purposes, which use is said to date back fifteen years prior to that. This French exhibit at the Centennial at Philadelphia seems to have been a seed sown on good soil, as a year or two later several inventors, like Brush, Thomson, Houston, and others, began electric arc lighting on a commercial scale. This was followed by great developments and very rapid progress, until at the present time arc lighting forms one of the large industries of the United States. After the very rapid developments of the first few years, progress in the arc lamp itself had been slow, but not unimportant. The chief developments were in the systems of distribution rather than in the lamps themselves.

At the electrical exhibitions of Vienna in 1883 and in Philadelphia in 1884 arc lamps were already well developed, and but little improvement has been made since. It was from the beginning of its general introduction, and is still at this time, probably the most efficient means of converting energy into light, though not necessarily the cheapest. Notwithstanding that it is a great waste of the energy of oil and coal gas to burn it for lighting, yet these are still important competitors of the more economical arc light, in several features.

In general, the direction of development of the arc lamps as shown by the exhibition is different in the Continental countries from that in the United States. In these countries the usual method of dis-

tribution of arc lamps is in multiple arc on constant potential circuits, the series distribution being quite rare; in the United States, on the other hand, it is quite the reverse, the former system being a great exception. This has led to a different direction of development of the mechanism of arc lamps abroad, as also to a much wider range of brightness.

Series lamps.—In a series system, such as is used in the United States, the current is constant throughout the whole circuit; as the potential of all arc lamps is nearly the same, and can not be varied to advantage, it follows that all the lamps in a circuit are of about the same candle power; furthermore, as one and the same current flows through them all, it makes all the lamps more or less dependent on each one. A lamp which could open the circuit would be fatal to such a system. Such a circuit is not easily broken while running, without total destruction of the parts where the break occurs, and consequent great fire risk on account of the persistence of the arc which forms at the break.

These conditions led to constructions of lamps in which such things can not occur, including safety devices and automatic cut-outs to prevent accidents, devices which are scarcely to be found in foreign arc lamps. In a series system it is the potential which varies as the carbons burn away, and which is therefore used as a means of effecting the regulation. The shunt coil is therefore the important one; the series coil, being traversed by a constant current, may therefore be, and in many lamps is, replaced by a spring or weight.

Multiple arc lamps.—In the multiple arc distribution many of these conditions are reversed or different. In such a system it is the potential which is constant and it is the current which will vary as the carbons burn away. The series coil is therefore the most important one for effecting the regulation, while the shunt coil could theoretically be replaced by a spring or weight. The lamps are independent of one another; no persistent arc will form if the circuit is opened; therefore no safety devices and cut-outs are required. As the current for each lamp is not necessarily the same, it has led to the development of arc lamps of small as well as very great candle power on the same circuits, requiring as little as two to as many as fifty ampères, making a much more flexible system, which also has the advantage that arc lamps can be put on the ordinary incandescent system without the special independent dynamo required in the series system.

It appears, however, that in practice arc lamps can not be run directly in multiple arc; such a distribution is found to require a dead resistance to be placed in series with each lamp; this resistance represents not only an additional piece of apparatus but a constant and considerable waste of power, which in general is about 20 per cent of the total power used, and in many cases as high as 30 per

cent. The system is therefore very faulty in this respect. This external dead resistance appears to be used not only to prevent the great rush of current should the carbons touch, as at starting, but it appears to be essential in some systems to effect a regulation, because in some lamps this regulation is effected by a shunt coil, which would be useless, because it would represent a constant force, were it not for this dead resistance. The regulation is in such lamps dependent on the variation of the loss of potential in this dead resistance caused by variations of the current in the arc, for if this dead resistance were zero there would be no change of potential at the poles of the lamp even if the current in the arc varied very greatly. This external resistance must therefore be considerable in order to enable the regulation to be effected by virtue of its resistance.

Feeding of the carbons.—Another feature which a multiple arc distribution seems to develop is that the feeding of the carbons must be a very gradual one and the regulation must be very sensitive, as a very slight change of the length of the arc makes a very appreciable change in the current, and therefore in the candle power. The foreign lamps are therefore essentially different from ours in that the regulation is a much more sensitive one, and consequently the light is very much steadier. Hissing and flickering, so common in our lamps, is the exception with these. The "drop" principle, which is the one almost universally used here, in which the carbon drops down suddenly during certain stages of the regulation, would be almost fatal to a multiple arc system. At the same time the foreign lamps are in many cases far simpler in their construction, even though the regulation is a much better one. This is to some extent due to the several safety devices which are necessitated by the series system and which are not necessary in the multiple arc.

In the usual system the arc lamps are either directly in multiple arc in constant potential systems of 70 volts, or two in series in systems of 110 volts. In the former the loss in the dead resistance is about 25 volts and in the latter about 20 volts.

One of the most frequently adopted principles of regulation of these lamps is that the carbon, in descending, by its own weight turns a multiplying system of gearing, the rapidly moving escapement of which is controlled by a brake which is operated by the magnet, usually series wound. The descent of the carbon may therefore be made very gradual and regular. Another principle frequently used is to force the carbon down, so as to make the action independent of any weights or friction. Make-and-break movements and small electric motors were also used in a number of lamps. The Jablochkoff candle still holds a prominent place, but apparently of diminishing importance. It still remains one of the leading of the very few alternating-current lamps.

New forms.—Although new departures from the usual arc lamps are attempted continually, there were none of importance exhibited except the new Pieper lamp, which, being really an incandescent lamp, is described under that heading.

Cored carbons.—Cored carbons are almost universally used for the upper or positive pole and plain ones for the lower. This also is one of the reasons why the lamps burn more steadily. They are only very little more expensive than the plain. (See "Carbons," under "General supplies.")

Small lights.—One of the interesting features of arc lighting exhibited was the more extended introduction of lamps of comparatively small candle power, requiring as little as three and even two ampères. They may be used to advantage to replace the large incandescent lamps.

Diffusion.—In a number of lamps both carbons are moved, the arc, therefore, remaining in the same position, which enables very small milk-white globes from 6 to 8 inches in diameter to be used for small lights. This diffuses the light in such a way that the effect is a much more satisfactory and agreeable one. A lamp of that kind may be placed over a table, or in even a small room, without being objectionable, and it does not hurt the eye to look directly at it. In another system the position of the carbons is reversed, so as to throw the light up against a reflector in order to diffuse it. It is claimed that when so diffused less light is required, because the pupil of the eye does not contract so much, nor are there such black shadows.

Exhibits by countries.—The exhibits of arc lamps were very numerous. Though mostly from France, there were many and very good ones from England, United States, Belgium, Switzerland, and one from Germany.

Cost.—The average cost of a good arc lamp abroad appears to be about $40.

DETAILED DESCRIPTION.

There were about as many lamps of totally different construction as there were exhibitors of lamps, an arc lamp being one of those pieces of apparatus of which it is very easy to invent a new and distinct mechanism. It would, therefore, be quite useless and uninteresting to give a detailed description here of more than one or two of the better ones, with a short summary of the more interesting points of some of the others. For complete descriptions the reader is referred to the journals and books in which most of them have been described.

Cance.—The Cance lamp exhibited by the Société Anonyme d'Appareillage et d'Éclairage Électrique (French section, gold medal), though not a new lamp, is of interest on account of its steadiness

and its wide range of candle power. The general principle of the lamp mechanism is shown in the adjoining cut, Fig. 5.

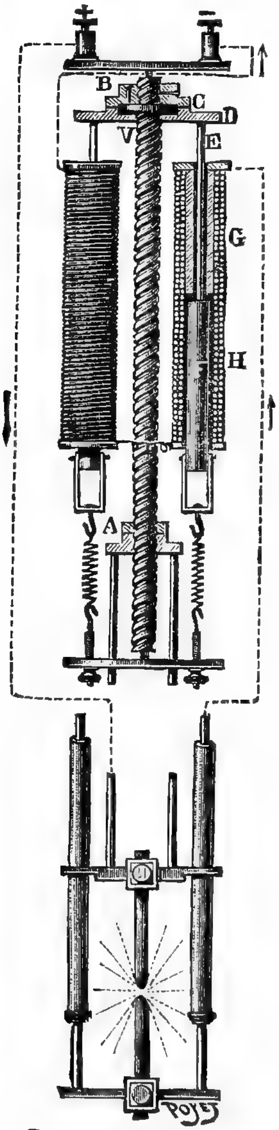

FIG. 5.—The Cance arc lamp.

It consists, in general, of a long square threaded-screw V with very great pitch, capable of turning easily. The nut A is attached to the upper carbon holder, which will descend slowly when this screw is allowed to turn; the screw is kept from turning by the second nut in the piece BD, which nut can turn only when the friction of the pressure on it, exerted by the piece BD, is released; this is done by the iron cores F in the solenoids; when the current in these solenoids decreases, the iron cores descend and relieve the upper nut, which can then turn and thereby allow the screw to turn and the nut A to descend, feeding the carbons. The two carbon holders both move, being suspended by means of a common cord over pulleys so that as the upper one moves down, the lower one moves up half as fast, thereby keeping the light in one place. The force for bringing the carbons together is produced by a weight, which is pulled up by the act of putting new carbons into the lamp. As it is a multiple arc lamp, the coils are in series with the arc, and no shunt coils are necessary. The lamps are made for a number of different currents, from 3 to 50 ampères. The light is particularly steady. As the arc remains in the same place, a very small white globe, only 6 to 8 inches in diameter (see cut of Bardon lamp below), can be used, which gives a very neat appearance and a very pleasant diffused light. The very small lamps of 3 ampères are an important addition to arc lamps, as it enables such lamps to be used in many cases where the usual large arc lamps would be objectionable.

Bardon.—The lamps of Bardon (French section, silver medal), shown in the following cut (Fig. 6), is interesting on account of its great simplicity. It is one of the simplest arc lamps in use. It consists simply of a brake actuated by a core in a solenoid, and pressing lightly against the circumference of the large wheel seen at the top,

which carries a small pulley on its shaft, over which passes the cord on which the carbons are suspended; the weight of the carbons tends to turn this wheel and it can do so only when the brake has been released by a diminution of the current in the solenoid. This regulation is said to be so sensitive and gradual that the wheel is turning slowly all the time; and an ampèremeter in circuit is said to remain quite steady; the feeding of the carbons can not be noticed by it. The lamp is, as usual, for multiple arc distribution, and has no shunt coil. The two carbon holders are, as in many other lamps, both movable, being suspended by a common cord over pulleys so that as the upper moves down the lower moves up through half the distance. This enables them to use very small globes, as shown. The arc is started by the whole wheel being raised by the brake, lifting up the upper carbon with it. The leads to the carbon holders are made with flexible cords and there are no sliding parts which need attention and cleaning.

Pieper.—In one of the Pieper lamps (Belgian section; gold medal) the upper carbon is pushed down by a make and break vibrator actuated by a shunt magnet. The spark produced at the make and break is scarcely visible. In another of these lamps there is a very ingenious escapement to the clockwork mechanism which permits the revolving escapement fan (and thereby the carbon) to move slowly, only; the escapement fan has attached to it a small weight which flies out and strikes against a stop when the wheel turns too fast: this makes the feeding very regular and gradual.

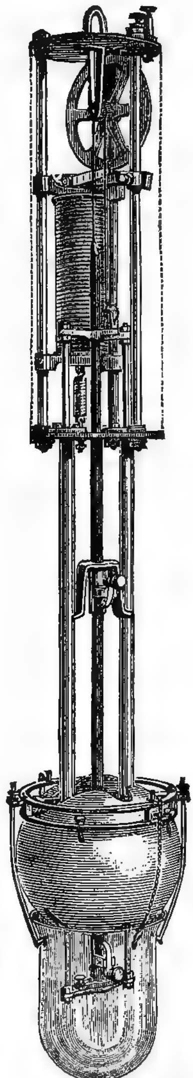

Fig. 6.—Bardon's arc lamp.

Maquaire.—The Maquaire lamp (French section; silver medal for lamp alone) is interesting on account of its very sensitive regulation and consequent steadiness. It is entirely independent of weights, clockwork, etc., and will run in any position. It is adopted and used by the French Edison Company. The upper carbon rod is actuated by a rack and pinion driven by a small electric motor. The lamp current passes through the magnets; the armature current is con-controlled by a contact piece resting normally between two contacts by the combined and opposing action of a spring and a magnet in shunt to the arc; when the arc is too short the spring predominates and closes one of these contacts and thereby turns the motor in one direction; when the arc is too long, the

magnet predominates and closes the other contact which turns the motor in the other direction. By making the distance between these two contacts very short, the regulation becomes very sensitive. It is made for multiple arc or for series distribution.

The principle appears good, except that for multiple-arc distribution it is not quite rational to actuate the lamp by a shunt coil, because this shunt coil should exert a constant pull or action, no matter what current is in the lamp, as it is controlled by a constant potential circuit. In order to enable a shunt coil to be dependent on the arc, there must be a resistance between the mains and the lamp, which means a waste. In other words, such a system requires as a necessary part of it a dead resistance in which energy is wasted.

Among the other claims are that the lamp is very short. They are usually run two in series on a 110-volt circuit, requiring 8 ampères and 45 volts, leaving a waste of 20 volts, which at 8 ampères gives 160 watts per two lamps, or almost as much as 3 ordinary incandescent lamps; this feature is, however, common to the multiple-arc system and not to this lamp only, except that in this lamp it is essential for the regulation. The upper carbon is cored, and is five-eighths of an inch in diameter and 7½ inches long; the lower is plain, seven-sixteenths of an inch in diameter and 6 inches long; they burn eight hours. The average price of the lamp is $40.

Breguet.—The Breguet "dynamo" lamp (French section) is perhaps the simplest in its principle though not in its construction. It consists merely of a small Gramme motor, with a small pinion on which gears the rack of the upper carbon rod. This constitutes the whole lamp; the weight of the rod tends to turn the motor and its turning force is balanced exactly by the tendency of the motor to turn in the opposite direction. The lamp is only for multiple-arc distribution. The motor is series-wound, but has also an auxiliary shunt winding, the object of which is said to be merely a damper to prevent too rapid a motion.

Aboilard.—In the Aboilard lamp (French section) the upper carbon rod is a long screw, the nut of which is turned by a make and break movement, whereby the rod is fed downward. It is therefore independent of any weights or position, and the regulation is by exceedingly small steps. The current is said not to vary more than one-tenth of an ampère while it is regulating.

Brown.—The Brown lamp exhibited by the Oerlikon Company (Swiss section) is also one of very simple construction. It consists, like a number of others, essentially of a brake which is applied to a large escapement wheel driven by the weight of the upper carbon. This brake is in the form of a wedge which is controlled by being inside of a very large coil of the full diameter of the lamp case. This large coil is intended to act by virtue of its self-induction to prevent too sudden changes in the current, and is therefore to re-

place the usual external resistance which is almost universal with arc lamps when in multiple arc, and which represents a great waste of energy. As there is a loss of 3 volts in this large coil, it has considerable resistance besides its self-induction. A good illustration and a description of the lamp will be found in l'Electricien, June 22, 1889.

Henrion.—The Henrion lamp (French section; gold medal) is one of the very few lamps exhibited which are usually run in series. The lamp itself is a slight modification only of the so-called and well-known Pilsen lamp. Both his series and his multiple-arc lamps are said to be exactly the same (both being differential) except that the former have a cut-out which switches equivalent resistances in circuit if the lamp fails. Among the multiple-arc lamps there were some of as low as two ampères, of which he claims to obtain six to the horse power. It appeared to burn quite nicely.

Crompton.—The Crompton lamp (English section; gold medal) is another lamp of exceedingly simple construction. It is for series distribution and often of as high as 25 ampères. It consists simply of a brake controlled by a differentially wound solenoid, and acting on a simple wheel escapement run by rack and pinion driven by the weight of the upper carbon holder. They are used very largely in England.

Thomson-Houston.—The Thomson-Houston lamp (United States section) differs from most others in that the carbons are at first separated; when the current is first started the mechanism brings the carbons together and separates them again to form the arc. The series coil is replaced by a spring, as the lamp is for series distribution only, in which, therefore, the series coil can not be used to regulate, as its action is constant.

Thomson.—In the personal exhibit of Elihu Thomson there was shown an alternating-current lamp, one of the very few exhibited. The upper rod having a rack descends by its weight and drives a clockwork mechanism; the escapement of this is stopped or released by a lever having a massive copper disk situated between the two poles of a shunt-wound alternating-current magnet. This copper disk is repelled by currents induced in it; when the current in the shunt magnet increases by the arc becoming too long this repulsion releases the escapement and allows the carbons to descend slowly. It was connected to a peculiar transformer which maintained a constant current in the secondary circuit on being connected to a constant potential primary circuit (see transformers).

Jablochkoff.—The Jablochkoff candle (French section) was the only other alternating-current arc lamp exhibited and one of the very few foreign arc lamps for series distribution. Formerly these lamps, consisting each of five candles, were run with as many wires, so that as each series of candles was burnt down the current was

switched on to another series until all five were burnt down. These multiple wires were objectionable and costly. Now they are run as follows: In the bottom of each lamp-post is a *series* transformer through which the constant current of the whole circuit passes. The secondary circuit of the transformer is connected to all the five candles in multiple arc through small lead fuses at the bottom of each. At the top of each candle the two carbons are connected with a carbon cement of high resistance; the current at first passes through all of these in multiple arc and burns out the weakest one which lights that particular candle, the others remaining as they were; the current passing through the others continually, and which is therefore wasted, is insignificantly small. As soon as that candle has burnt down to its holder, the heat of the arc melts the fuse at this point, which cuts out that lamp; the current must then pass through the others, lighting the one of lowest resistance, and so on until all have been consumed.

Sautter, Lemonnier & Co.—The arc lamps of Sautter, Lemonnier & Co. (French section), used for their well-known search-light projectors, are all usually hand regulators, the carbon holders being moved simultaneously by being secured to two nuts on a common screw, one part of which has a right-hand thread and the other a left-hand one of double the pitch. The carbons in these are not directly opposite, as usual, but are slightly out of line so as to form the crater of the arc on one side of the positive carbon, in order that the full light of this crater shines directly onto the reflector without any obstructions. The arc for their large 60 centimeters reflector is said to be of 60,000 candles without the reflector. They find that the maximum light is given with 55 to 60 volts; higher voltage gives even less light. For the smaller 30,000-candle light it is found to be 50 volts.

The Mangin reflector for these projectors, as is well known, is in the rear of the arc and is composed of a lens, the rear side of which is a reflector. The light is therefore refracted twice and reflected once, thereby enabling a smaller lens to be used than if it was refracted only once. All the light from the arc passes back to this reflector; there is no direct light from the arc. The flashes for signaling by means of these projectors, for instance by Morse character, are produced by a small hinged iron screen, which is placed between the arc and the reflector, thereby completely cutting off the light. The following figures regarding these projectors may be of interest: There are 4 sizes, 30, 60, 90, and 150 centimeters in diameter (12, 23½, 35½, and 59 inches, respectively). The power of these is as the squares of their diameters, the third being therefore about twice the second, and the fourth being about seven times the second. Although the rays from the projector should be quite parallel, they do make a small diverging angle, the size of which is one degree

and a half; this is due to the fact that the arc has an appreciable size and is not a mere point. There is no spherical aberration, the composite reflector being the equivalent of a parabolic mirror. The formula for calculating the candle power of the beam of light at different distances is—

$$\frac{A^x}{x^2}$$

in which x is the distance and A is a fractional constant depending on the atmosphere; for an absolutely clear atmosphere A is equal to 1. For a moderately misty atmosphere, such as that around Paris, A is about 0.8. For calculating the apparent illumination of a distant place, as seen by the operator at the projector, this formulæ must be squared; as the distance is doubled, it therefore becomes—

$$\frac{A^{2x}}{x^4}$$

in which the symbols stand for the same quantities. With the small 30-centimeter projector the operator can see objects on a clear night 1,000 meters distant (3,280 feet). The arc of the 60-centimeter projector has a candle power of 60,000 candles without the reflector; with the reflection it is increased 1,100 times, or equivalent to 66,-000,000 candles. The 150-centimeter projector, which was in operation continually during the exhibition, from the top of the Eiffel Tower, is about seven times as powerful; the direct light from it hurts the eyes even from a distance of several miles. The above figures were obtained from the makers.

Meritens.—In the exhibit of Meritens & Co. (French section, gold medal), who are the well-known pioneers in electrical light-house lights, were shown some carbons 2½ inches in diameter for 600 ampères and 45-volt lamps for light-houses, which are made of a large number of rods of square cross section tied together to form one. They claim that these composite carbons burn more evenly for such large sizes.

Le Blon.—The arc lamp of Le Blon (French section) was practically without any mechanism. It consisted of two carbon holders in the form of two pivoted levers like a pair of scissors held vertically, having carbons fastened perpendicularly at their lower points. The carbons rest against each other at their extremities and glow at this point; their weight feeds them as they are consumed. It should be used with an alternating current. In another form the carbons are curved and are forced together by a weight on a string over pulleys on the holders. It is a question, however, whether a true arc is formed, or whether, as is more likely, it is more of an incandescent light. They were not running, and were probably experimental only.

Puvillard.—The lamp of Puvillard Frères (French section) was somewhat similar, having two curved carbons fed by clockwork,

the escapement of which was controlled by a shunt-wound magnet. The clockwork had to be wound up. The two curved carbons were in two different inclined planes, touching at the intersection of these planes. It was a very short lamp, with the arc at the top, to be used as a table lamp.

Arnould.—In the Arnould lamp (French section) the arc is surrounded by two concentric cylinders of glass, the outer one being closed at the bottom. The object is to make the air for the lamp pass down between the two cylinders and become heated before it passes by the arc, whereby it is claimed greater efficiency is obtained.

Dulait.—In the lamp of Dulait (Belgian section, gold medal) the position of the carbons is reversed, the postive or bright one being the lower, so as to throw the light up against a conical reflector. The principle is that if a light is diffused over a great surface the pupils of the eyes of persons do not contract as they would if the light were all from one small point, and that, therefore, less light will be necessary to produce practically the same illumination as far as the eye is concerned. It furthermore illuminates to greater advantage, as it casts no dark definite shadows. He claims that the gain in this diffusion of the light is greater than the loss attending the reflection, and as a result a smaller number of such lamps is required in replacing the usual lamps by these.

Alioth.—The Alioth lamp (Swiss section) is claimed to burn fourteen hours with one set of carbons, although they are only about 8 inches long. The upper one has a cross section more than twice that of the lower. The upper one is always cored. It is not stated to what this long life of the carbons is due, but it is presumably owing to its being a small current lamp.

References.—For carbons see "General supplies." For "illuminated fountains" see "Miscellaneous applications of electrical energy." For "systems of distribution" see under that heading.

INCANDESCENT LAMPS.

Development.—The introduction of the incandescent lamp as a commercial lamp may be said to have begun between ten and twelve years ago, although it was known and had been used a number of years prior to that, yet it had not been developed sufficiently to come into general use.

One of the most important steps in its development, made at that time, was to make the incandescent carbon long and slender instead of short and thick; this was without doubt that which made it a practical success as a commercial lamp. This step is claimed to have been made by Edison. After the very rapid development of the first few years of its introduction, but little progress has been

made other than minor improvements in details of construction and manufacture, which naturally accompany the manufacture of any article on such a great scale. The potential almost universally adopted is about 100 volts. The efficiency has been increased but little in the last five or six years; it is at present as a rule between 3 and 3.5 watts per candle for the usual lamps, and in some cases as low as 2 watts for large lamps with thick filaments.

As a converter of electrical energy into light, it is still very inefficient; an arc lamp will give from five to ten times as much light per watt as the incandescent. It is claimed to have been found that only a very small fraction of the electrical energy of an incandescent lamp is converted into light, almost all of it being converted into heat. If this is the case, and it seems likely, it is a great waste of energy to produce light with incandescent lamps, in the same way as it is a great waste to use gas for illuminating purposes, or even to use coal for driving steam engines. There is therefore very much room for improvement of incandescent lamps, which will probably be in its being replaced by a radically different lamp, rather than in improvements of the present form. Some development in this direction was shown by the small arc lamps of low candle power, requiring as little as two ampères. But although the latter have such a very much higher efficiency, yet they do not compare to the incandescent lamp in convenience. The latter feature is of such great value in favor of the incandescent lamps, that the arc lamps are even being replaced to some extent by large incandescent lamps of 1,000 and 2,000 candles.

Another direction of development shown is in the radically different incandescent lamp exhibited by Pieper, which belongs to the so-called semi-incandescent lamps, though it is truly an incandescent and not an arc lamp. This lamp is said to require only 1 watt per candle. Among the incandescent lamps exhibited were some Khotinsky lamps of 150 to 200 volts and of the usual candle power. If these are in all other respects as good as the usual 100-volt lamp it is an important advance, as it cheapens the distribution very greatly.

The manufacture of incandescent lamps is at the present time already one of the largest branches of the whole electrical industry; several makers in France alone claim to be making lamps at the rate of 2,000 and 1,000 per day. In Germany, as also in England, the quantity is doubtless still greater, while in the United States there are probably as many made as in all the other countries combined.

Exhibits by countries.—There were altogether about eleven exhibitors who manufacture the lamps themselves. Of these, three (Edison, Thomson-Houston, and Heissler) were from the United States, the rest were almost exclusively from France, though the inventors of some were from other countries.

DETAILED DESCRIPTION.

As the processes of manufacture are usually—and wisely, too—kept secret, the following detailed description is limited to a mere mention of some of the data of the respective lamps:

Edison.—In the Edison exhibit (United States section, grand prize for whole exhibit) there was shown a well-arranged and complete exhibit of the various steps in the manufacture of the lamps, from the crude material to the finished lamps. There were stated to be twelve hundred varieties of bamboos, of which three hundred are useful. A particular one of these found in a certain hilly district of Japan, after a certain age of growth and seasoning, was found to be the best and is the one at present used. The inner pithy fibers and the hard, siliceous outside are planed off, leaving the inside, from which the straight filaments, with their widened terminals, are cut to an exact size. These are then bent, carbonized, and connected to the leading-in wires by electrically deposited copper.

Lamps are made of 4, 6, 8, 10, 13, 16, 20, 24, 32, 50, 100, 150, 250 candle power, all for the same circuits of about 110 volts. The lamp manufacture has become a very large part of their industry. Some idea of the extent of this may be had from the fact that at the close of the year 1888 they had 434,181 lamps installed in isolated plants alone, which was almost double that of the preceding year, 230,674. Besides these there were 675,660 lamps in central stations and 15,550 in municipal plants, making a total of about 1,125,000.

French Edison-Swan lamps.—Probably the next largest lamp manufacturers of those exhibiting is the Compagnie Générale des Lampes Incandescentes (French section, gold medal), who manufacture under the combined Edison and Swan patents in France. Their capacity is 2,500 lamps per day, employing 200 hands and using 250 horse power. They make chiefly two styles of lamps, one with a plain horseshoe filament like the Edison, and one with the filament in the characteristic loop form of the Swan lamp. Their usual lamps are made for 10, 16, 32, and 50 candles; they have also introduced larger ones of 100, 200, 500, and 1,000 candles. They are made of various voltages from 2 to 200 volts, at an efficiency of from 2 to 4 watts per candle; the types generally used consume 3.5 watts per candle, while the larger ones require only 3 watts; the life is said to be 1,000 hours. For special cases in which greater economy is desired at the expense of life, the consumption is reduced to 2 watts per candle, with a life of 500 to 600 hours.

The large lamps of 1,000 candles are introduced to replace the arc lamps, which are objectionable in many cases. The cost of such a lamp is $6.75, and assuming a life of 800 hours, this corresponds to 0.85 cent per hour for the cost of the lamp; the cost of the consumption of carbon alone in an arc lamp they give as about 2 cents per

hour, showing considerable saving in favor of the incandescent lamp. Besides this there is the cost of the arc lamp and the cost of attendance, which is by no means small. On the other hand, the consumption of power for arc lamps is considerably less, being only about one-half watt per candle, as against 3 watts for the incandescent. Besides this the cost of the circuit and of the transmission of the same amount of power for arc lamps in series is less, but in Europe they usually run arc lamps on the usual multiple arc circuits, so that this factor does not enter there. They also make focus lamps to be used with reflectors, for search lights for instance, in which the filament is in the form of a closely wound spiral, so as to have the light as nearly as possible condensed in one point.

Gabriel.—Another large exhibition of lamps was that of F. Gabriel. (French section, honorable mention.) He claims 3.5 watts per candle for the usual sizes and down to 2.5 for the larger ones, at 800 to 1,000 hours. The filaments are made of gun cotton. The base is of a black glass or enamel, with a bayonet clamp or holder and two exposed flat contact surfaces on the bottom, making a very simple and practical lamp base, which is used also by a number of other makers.

Lodyguine.—Lodyguine, who was one of the earliest, if not the earliest worker in this field, has a small historical exhibit in the Russian section (gold medal), showing chiefly the various substances with which he had made lamps. Among these were caen cloth, raw flax, silks, broom weed, lime-tree wood, fiber from the dwarf palm leaves. The material used now appears to be couch grass or weed grass. The joint of the carbon with the leading-in wires is made of a carbon cylinder having the wire twisted around the outside and the filament inserted through the center.

Cruto.—The Société Anonyme pour le Travail des Métaux (French section, silver medal) exhibited the Cruto lamp, which is made of a fine platinum wire, on which the carbon is deposited by heating it in a hydrocarbon gas. An interesting novelty was a glass bulb for the lamps, which was corrugated, or formed with numerous ridges, small projections, and depressions, in such a way that the light from the filament was broken up into a large number of bright points and was thereby diffused as in the usual ground glass or milky bulbs, but without suffering any loss, as the glass was quite transparent.

Gérard.—The Société Anonyme d'Électricité (French section, gold medal) exhibited the Gérard lamp, in which the filament is made of two straight carbon rods cemented together at their upper ends. The rods are made from a paste like arc-light carbons. They are mostly for low voltages varying from 6 to 33 volts, and up to 100 for the very large lamps. Their efficiency is stated to be 3 watts per candle.

Khotinsky.—Daniel Augé (French section) exhibited the lamps of Khotinsky. This is the only lamp exhibited which is made for as

high as 150 and even 200 volts, and as small a current as 0.16 ampères for small candle powers down to 5 candles, with the usual efficiency of $3\frac{1}{4}$ to $3\frac{1}{2}$ watts per candle. If these lamps are as good in life and mechanical strength as those usually made, it is a very important and valuable improvement, as it reduces the size of the conductors to one-half and one-fourth of that required by the usual 100-volt lamps. They claim to make 2,000 lamps per day, employing 300 hands.

Sunbeam.—The "Sunbeam" lamp, exhibited by A. Janssens (French section, silver medal), is a large lamp for from 150 to 2,000 candles, with an efficiency of from 2 to 2.5 watts per candle, the chief use for which is to replace the arc lamp. For 800 candles and less it has one filament, and for greater candle powers there are two filaments in derivation in the same bulb.

Pieper lamp.—One of the most interesting lamps, on account of its simplicity and novelty, was the Pieper lamp (Belgian section). It consists essentially of two copper rods about like lead pencils, secured one opposite to the other like the two carbons of an arc lamp, only that they are horizontal. Their ends are separated by a small space of about an eighth of an inch, as if to form an arc between them; their other ends are supported by springs so as to allow for a slight upward motion of the free ends. One of these is connected to the positive and one to the negative pole of a circuit. Over the small space separating the ends of these rods, where an arc would otherwise form. rests a vertical carbon rod which touches both of these ends and forms a bridge over them; the current therefore passes over this space through the end of the carbon rod, thereby keeping it at a white heat; as the carbon burns away it feeds itself by its own weight, it being held in a vertical tube. There is, therefore, no regulation of any kind necessary, and the whole mechanism is reduced to an exceedingly cheap and simple device. Should the carbon rod break off, or refuse to feed down, the ends of the two copper rods will move up until they touch a metallic bridge piece which thereby short-circuits the lamp to prevent its interfering with others in series with it. The carbon rods are of special construction, resembling two thin rods united together on one side, quite similar to a Jablochkoff candle, only that they are entirely of carbon.

The following figures were given by the exhibitor and are said to have been taken from an expert test: With 10 volts and 20 ampères it gave 200 candles, which corresponds to an efficiency of 1 watt per candle, or from two and a half to three times as good as an incandescent lamp. The carbon is consumed at the rate of 2 inches per hour, one carbon lasting eight hours. It appears to be quite new, and there was, therefore, no opportunity to discover any weak points. It is a question how the copper will stand the heat; it is supposed to conduct the heat off rapidly enough to prevent the copper points

from being injured. For an illustration of the lamp, see Industries, September 13, 1889.

References.—For systems of distribution, see under that heading.

SYSTEMS OF TRANSMISSION AND DISTRIBUTION.

General.—Apart from the exhibits in the United States section there was very little at this exhibition which was of novelty or importance in systems of transmission and distribution of electricity. In the United States section there were more different and distinct systems exhibited than in all the other sections together. To an American it was strange to see how little attention was given to this subject abroad, if the exhibition can be said to represent the state of the art there. Almost the only system in use there for lighting seems to be the multiple-arc system in its original simplicity. Series systems, or the more complex systems, or those in which there is a conversion, were limited to a very few isolated exhibits of less importance. This may be partially due to the fact that they are averse to high-tension currents on account of their danger to life, and that they hesitate to introduce any improved system until it has been well developed and introduced by the less conservative Americans. England alone appears to be an exception. One of the characteristic features of the United States exhibits was that they were developed in all details with all necessary accessories to make the system complete and practical. In complete systems of transmission and distribution, America had more to teach than it had to learn at this exhibition.

Incandescent lamp distribution.—Aside from the United States exhibits described below, the only systems exhibited in operation were the simple multiple-arc distribution, the three-wire system, and an unimportant converter system. In one case several small incandescent lamps were run in series on multiple-arc mains, but as there was no cut-out or regulating device of any kind, it can not be called a system. Series distribution of incandescent lamps, of which there were three American exhibits, seem to be almost unknown in France. Even the simple three-wire system does not appear to be used very much, and the alternating converter system, though used, was not exhibited in operation outside of the United States section. For some introductory notes regarding the latter system see "Transformers."

Arc lamp distribution.—In the European exhibits, arc lamps were almost universally run on the same multiple-arc circuits as the incandescent lamps; in those cases there was one lamp on a 75-volt circuit or two in series on a 100-volt circuit; in either case there was almost always a dead resistance in circuit, in which from 20 to 30 per cent of the power is wasted. The advantages claimed for such a distribution are that the arc lamps may be on the same mains

with the incandescent, and that the potential is therefore as low and safe as that for incandescent lamps. The great advantage which our usual series distribution has over it, besides the economy of power, is the considerable saving of wire, not only in size but also in length, as in many cases the series circuit is single, while the multiple-arc circuit must always be double. The multiple-arc system has the advantage that the lights are less dependent on each other, but in any good series system, as installed by the better companies here in the United States, there is very seldom a complete failure all along the circuit, due to one bad lamp.

For a further comparison of these two systems see the paragraphs on series lamps and multiple-arc lamps, under the heading "Arc lamps." With the exception of the Jablochkoff candle system and one or two less important exhibits, the series arc-light systems were limited to two from the United States (Thomson-Houston and Sperry) and one from England (Crompton). There was nothing of novelty in any of these, and their description has therefore been omitted. The almost total absence of this cheap and convenient system among the European exhibits was very noticeable to an American.

Power transmission and motor distribution.—Apart from the exhibits in the United States section, there was scarcely a single exhibit of importance of a complete system of distribution of independent motors. There were quite a number of transmissions of power by means of motors, but they consisted of a single generator driving a single motor, and therefore can not be called a system of distribution. The generators and motors were generally both series-wound machines, the motor being started by means of an auxiliary resistance in series with it, which was gradually cut out as the motor reached its proper speed. In one of these "systems," the well-known name of which need not be mentioned here, some of this resistance was at the generator station and had to be kept in circuit all the time.

In the distribution system exhibited by the Thomson-Houston Company the motors were run from the usual multiple-arc circuits. The motors were shunt wound, and were started by a switch which first put the field into circuit, then the armature in series with a resistance, and then gradually cut out this resistance as the speed increased to its normal value. The reverse operation stops the motor. As the results from opening the field circuit first might be very disastrous to the motor, this switch forms an essential part of such a system.

Railroad systems.—The electric-railroad exhibits were limited to two very good ones from the United States and one from Belgium. When compared with the large number of electric railroads in the

United States, those in Europe are so few in number that this branch of electrical engineering can hardly be called an important industry there.

DETAILED DESCRIPTIONS.

Edison system.—In the exhibit of the Edison Company were shown many of the details of their regular multiple-arc three-wire system. As this has been so fully described in the technical journals and is so well known here in the United States, it is not necessary to describe it. It might be mentioned here that the balance of the lines is effected by means of very large resistances of iron wire at the station, which are in the form of spiral coils, so grouped and connected to the multiple-contact switch that by moving the switch lever to successive contacts the same coils are variously grouped in multiple-arc or series, according as the current is greater or less, the total successive resistances varying in regular steps. By this means of always using all the coils much wire and space are saved, as the current capacity must sometimes be very great. Some of the special instruments used will be found described under "Instruments."

Five-wire system.—A descriptive note of his five-wire system states that "any lamps of one branch may be thrown upon any other branch to equalize the load, the controlling apparatus being in the center station." The way this was done was not, however, described, nor was the system exhibited.

Municipal system.—The Edison municipal system of incandescent lighting in series is for streets, parks, public squares, etc., in which the number of lamps burning is approximately constant. The dynamo has 1,000 to 1,200 volts. The circuits from it are in several multiple-arc branches, of 3 ampères each, and are kept constant. Machines are made for four, eight, and twelve circuits. In each of these circuits all the lamps are in series. Each lamp has an automatic cut-out in its base, which short-circuits the lamp in case of breakage or failure. At the station each circuit has its ampèremeter, which rings an alarm if current increases, due to the cutting out of a lamp. The attendant then switches a lamp into that circuit at the station to restore the balance. The lamps on the same circuit may of course be of different candle power, and may be rated at about 1 volt per candle, making about 1,000 candles per circuit. Some of these circuits are 10 miles in length; they are of No. 12 wire.

Thomson series incandescent system.—The Thomson-Houston Company exhibited a system of incandescent lamps on series circuits. The only special peculiarities are that the act of screwing in a lamp opens a switch in its base which otherwise short circuits it. In order to cut out a lamp which fails while burning, there is in

each base a spring contact which is insulated only by a thin piece of paper; should the lamp fail, the potential developed at its poles, that is, at this contact, would momentarily rise so high as to pierce the paper, thereby making contact and short circuiting the lamp.

Heissler.—In the Heissler system (United States section, gold medal) the alternating current machine has two independent circuits of 5 ampères each. These are kept at a constant current strength. In each of these there are 5-ampère incandescent lamps in series and of different voltages depending upon the candle power. They are all supposed to be kept burning at one time, though a few may be turned off in each branch independently, or any desired number if the same number is cut out in each branch.

A double regulator run by a small belt, and operated by two series magnets, one in each circuit, switches a resistance into and out of each of the two main circuits to regulate the currents independently, that is, to balance them; it also regulates the exciting current of the dynamo when both circuits are to be adjusted in the same direction. The dead resistance is, therefore, used only when there is an inequality in the two branches; whenever both vary the same, the exciter is regulated. The regulator performs both of these operations automatically. Each lamp has a small cut out in its base, which consists merely of a small electromagnet, which will short circuit the lamp if it should burn out or be broken; it operates equally well if the lamp is broken or removed before the current is started, a case in which some other systems fail.

The filaments of the lamps are all the same diameter, but vary in length, depending on the candle power. The filaments being much thicker than usual with 100 volt lamps, they are less frail and can be run at a higher temperature and therefore at better economy, from 2.5 to 2 watts per candle. The chief application is for long distance transmission and for buildings and places in which the number of lamps burning is not varied very much. Its advantages are its simplicity, the great saving of wire for long distances, and the greater efficiency of the lamps.

Multiple series system.—The Thomson-Houston Company exhibited a multiple series incandescent system, in which the incandescent lamps are run in groups of several in multiple arc, the groups being in series on the usual series distribution system, with arc lamps. Each lamp has in its base a cut-out and a resistance equivalent to that of the lamp. Should the lamp fail, the cut-out will automatically switch this resistance in the circuit to replace that of the lamp. The resistance is ingeniously arranged on small pieces of mica so as to take up as little room as possible in the base of the lamp, and at the same time to cool off as freely as possible.

Accumulator.—The Société Anonyme pour la Transmission de la Force par Électricité exhibited a system in operation in which the dynamos for direct lighting in the evenings were used in the day-

time for charging accumulators, whose current was then available in the evening or at any time during the day. The cells were in several series groups, which groups were connected in multiple arc. The last twelve cells of the series were connected separately to a twelve contact switch board, by means of which one after the other could be added or cut out to keep the potential constant. There was such a switch board for each of the multiple arc circuits leading off from the accumulators, but all were connected to the same twelve regulating cells.

Transformer system.—The Thomson-Houston Company exhibited their alternating current transformer system. The transformers were in multiple arc on the primary, having 1,000 volts. The transformers reduced this to 50 volts. The system itself did not differ materially from the usual one, and therefore needs no description here. For a description of their transformers see under that heading. The French Edison Company use for long distances the Zipernowski-Deri-Blathy system of alternating current transformers. The primary has 1,000, 2,000, or 3,000 volts, and the secondaries 100, 75, or 50. The system was not exhibited in operation.

Thomson Compensating system.—The only system of distribution exhibited which was quite novel in principle was the ingenious one of the Thomson-Houston Company called the "compensating" system. It is for the general distribution of incandescent lamps by alternating currents, permitting any to be turned off at will. The object is to reduce the cost of wire from the dynamo to the centers of distribution. The general arrangement is shown in the adjoining cut, Fig. 7.

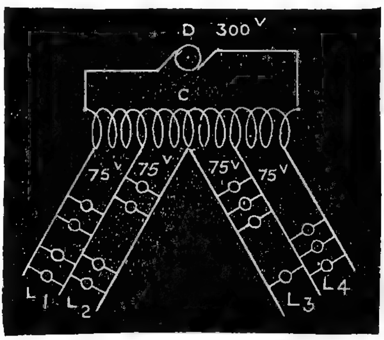

FIG 7.—Diagram of the Thomson compensating system of distribution.

The self-induction coil C is like an ordinary transformer, but with only a single coil. Branch wires lead off from the ends and from three points in the coil, as shown, which form two three-wire systems of distribution for 75-volt lamps. This coil is placed at the center of distribution of that set of lamps, and is in multiple arc with others like it, across the 300-volt mains from the dynamo. The four sections of this coil each act as a compensator for the lamps in multiple arc with it. Each section will keep the potential of its lamps constant, no matter how many are turned off, and it will furthermore be independent of any of the other sections.

The power consumed is said to be proportional to the number of lamps burning, as the apparent loss of current in the coil is not a real loss of energy. There must be some loss, however, when all

the lamps are turned off, but how much the writer could not ascertain. It was stated that the efficiency was 95 per cent. but this is probably when the full load of lamps is running.

The dynamo for supplying the current was interesting on account of its being a compound wound alternating current in which the alternating current was redressed, passed through the series coils and redressed again (see dynamos). This system permits therefore of running 75-volt independent lamps with a 300-volt current of one-quarter the strength in ampères, thereby reducing the weight of the feeding leads to one-sixteenth of what it would be in the simple multiple arc distribution. Such a direct comparison is, however, misleading, as the disposition would be chosen differently if the ordinary system were to be used, thereby reducing this apparently very great difference somewhat, but nevertheless leaving a great margin in favor of this compensating system.

Long-distance transmission.—Another ingenious system was exhibited by the Thomson-Houston Company for transmitting current to a distant center of distribution. It was in operation for transmitting and distributing power and light to the American agricultural exhibits, situated several thousand feet from the generator. It was the only exhibit in operation of a true system of distribution of light and power at a distant center; the only other exhibit of long-distance transmission was merely a simple series system in which the motor was used to drive a line of shafting, there being, therefore, no distribution other than that by shafting.

This Thomson-Houston system consisted of a 220-volt generator, a long-distance two-wire transmission to the center of distribution, and a special redistribution which changed this two-wire circuit into a three-wire one of two branches of 110 volts each, from which lights or motors were run as usual. This redistributor consisted of a single motor-dynamo having two windings and two commutators on its armature; these two armature circuits were connected in series with each other, the double motor being then run as usual from the 220-volt circuit, the single field being in shunt. The three-wire circuit was connected to the poles of this motor, the neutral wire being connected to the junction of the two armatures. This divided the 220-volt circuit into two branches of 110 volts each; the double motor, by virtue of its action, both as a motor or a dynamo, keeps the two circuits balanced and at a constant and equal potential, no matter how many lamps are turned off.

Oerlikon power transmission.—In the system for the transmission of power exhibited by the Oerlikon Company, which is being introduced extensively, especially in Switzerland, there is one generator and one motor, both are series wound and are connected in simple circuit. The largest machines used are from 250 to 300 horse power, which were the ones exhibited. (See Dynamos.) For greater

power they use two or more generators and the same number of motors, the transmission being then on the principle of the three or more wire system.

The system is said to be self-regulating for variable load without any additional regulator, both machines being series wound. The only difficulty seems to be in starting the motor, which must be done slowly and carefully. They always have telephone connection between the two stations for this reason. The motor is readily stopped by opening the circuit at the motor or by short-circuiting the field of the generator. As there can be but one motor in such a system, it is limited to power transmission, as distinguished from power distribution. For a report of a test made of such a system in operation, see La Lumiero Électrique, 1888.

ELECTRIC RAILWAY SYSTEMS.

There were three systems of electric railways exhibited, the Thomson-Houston and the Sprague from the United States, and the Julien from Belgium.

Thomson-Houston.—The one exhibited by the Thomson-Houston Company included a full-size truck and all details and accessories for the transmission. The system was one with a single overhead wire and trolley, the ground being used as a return. The exhibit was quite complete in all details, including the systems of overhead conductors, with its crossings, switches, trolley, etc. There was one motor for each of the two shafts; the fields were wound in sections; the controlling switch included a series of resistances made of plates of iron closely clamped together, which served to start the current gradually. At the end of this switch where the current was broken there was an ingenious device, consisting of a magnet, which acted to "blow" out the spark produced on opening, the magnet being itself put into circuit by the switch. The reversing switch was separate. The motors were pivoted on their shafts, and at the other end were secured by rubber cushions, allowing for a slight play. The brushes were of carbon, quite radial and fixed in position. There was an intermediate shaft and a train of four gear wheels. Those on the main shaft were split to facilitate removal; the pinions were made of alternate disks of steel and rawhide one-fourth of an inch thick. The bearings were surrounded by a hollow box, which was constantly full of oil. The whole motor gear was protected from dust by a casing of sheet zinc. The poles are 100 to 125 feet apart; the trolley wire is reënforced as a conductor by a feeding wire connected to it at numerous places. The cars are all in multiple arc on a 500-volt circuit.

Sprague.—The exhibit of the Sprague system, likewise for overhead trolley-wire distribution, included the truck and the switch.

There were two motors, one for each shaft, suspended on the shaft at one end and on springs at the other. There was one intermediary shaft. The motor pinions were of vulcanite, to avoid noise. The gears on the main shaft were split, and those on the others were on the projecting ends of their shafts so as to facilitate their removal. The brushes were of carbon, partly tangential, fixed in position, and with spring feed. The fields were wound in sections. The controlling switch or commutator for starting and reversing was of special construction, consisting of a succession of contacts on the surface of a cylinder, representing the sections of the field, the armature, and the line; by turning this cylinder the current was switched to the field sections grouped in various ways from multiple arc to series, so as to start the motors gradually. The oiling was done with fat or tallow.

Julien system.—The Julien system was for use with accumulators. It consisted of a complete car and a separate truck. The front end of the car rested on the pivoted driving truck having four wheels; the rear end rested on two fixed wheels, as usual. The truck had one series wound motor whose pinion geared with an annular wheel with wooden teeth; this was on the same shaft with two pinions which geared with chain gearing to the two truck shafts. The motor develops 3.5 effective horse power. The brushes were fixed and were made of copper foil. The battery consisted of 120 Julien cells under the seats. The starting and reversing was done by one switch, and the changing of speed by another. The latter was accomplished by different groupings of the cells, in multiple arc, multiple series, or simple series, in such a manner that the electromotive force could be varied without losses in dead resistances and that the cells should discharge equally.

Accessory.—Van Vloten, in the Belgian section, exhibited a small model of a very complete system for shifting the boxes of accumulators out of and into the car. It consisted essentially of a roadbed of rollers, on which the boxes could be moved readily, parallel to the car, thence into the car by means of turntables and a short truck, which could be raised or lowered slightly to the exact height of the car.

INSTALLATIONS.

All the parts, including systems, which compose an installation having been described under their proper headings, there remains to be mentioned here merely the installations, as such. Although there were many of these, they were almost all so small and simple that there is nothing left to describe. A few of them were more of the nature of a central station; but as it can hardly be expected that central stations in all their details be erected for the short period of the Exhibition, it would not be fair to judge these as model central

stations, for, as such, most of them could not be criticised favorably in many of their features, at least from an American point of view.

With the exception of the accessories of central stations, exhibited in the American and English section, the chief installations were all French. The best and most complete exhibit in operation was that of the Continental Edison Company (French), and this may be said to be a good model of a central station in almost all of its details. Most of the other large installations in operation may serve very well their purpose at the Exhibition, but they can not be considered favorably as standard models of a central station for general distribution, complete in all details. In general, they may have been designed well enough for the particular service for which they were intended, provided no accidents happen, but there was not sufficient flexibility in the installations to meet the requirements of a central station for general distribution, such, for instance, as provision against accidents, stoppages, provisions for reserve power, repairing, extensions of the system, etc., without which a central station does not deserve its name.

Most of the larger installations at the Exhibition were described and illustrated in the numbers of the (London) Engineer for the latter half of 1889, and it is, therefore, thought unnecessary to do so here, especially as such a description would be of little value unless it is a very detailed one, as it is the details which make a central station.

Almost all the wiring in the Exhibition grounds was underground, either by means of lead-covered wires laid directly in the ground, or by rubber-covered wires in troughs, and in some cases directly in the earth, or by provisional wooden conduits, in which they were supported on insulators. The wiring in the buildings was hidden very neatly so that it was not noticeable.

The central station of the Compagnie Continentale Edison was by far the most complete exhibit of a model central station. An illustrated description will be found in the Engineer, October 4 and 11, 1889. It resembled in many respects, in its completeness, a typical American central station, and showed, in its general arrangement and details, considerable experience in central station work, which can not be said of a number of the other large installations exhibited. The distribution was by means of a three-wire system only, with tandem dynamos. It differed from the usual system of universal mains, in that the more important centers of distribution were connected to the station by independent mains with separate switches; the loss allowed was 10 per cent. Arc lamps were run four in series between the 200-volt mains.

The central station of the Société Anonyme pour la Transmission de la Force par l'Électricité included a large installation of accumulators which were charged in the daytime by the engines and dy-

namos which would otherwise be idle. In the evening they added their stored energy to that from the dynamos direct, thus increasing the capacity of the station. This system is described under "systems." Their central station in Paris is to be operated on a similar system.

The station of the Société l'Éclairage Électrique comprised a number of independent systems, including a continuous-current three-wire system, a direct and a series transformer system for Jablochkoff candles, motors, etc. It was more in the nature of a general exhibition of their various systems, rather than a typical central station for general distribution, from which latter point of view the station could hardly be considered very favorably.

The small installation of Crompton & Co. (English section) was no doubt the most compact installation at the Exhibition—that is, having the greatest output for the smallest floor space, and included a one-third reserve force. It was, furthermore, one of the very few installations of a series arc lamp distribution. There was also a small batch of incandescent lamps on a three-wire system from 220-volt dynamos in multiple. An illustrated description will be found in the (London) Electrical Engineer, August 2, 1889.

LIGHTING OF THE EXHIBITION.

The opening of a large part of the Exhibition in the evening necessitated its being lighted. This brought up the question of how and by whom it was to be done and how it was to be paid for. It was finally decided to give the exclusive right to a French syndicate, which was to receive in return in the neighborhood of half the receipts from admission in the evenings. Shortly before the opening of the Exhibition, and after most of the preparatory work of this syndicate was finished, a change in the financial management of the Exhibition compelled the syndicate to sell their right to a share of the admissions back to the administration for a fixed sum.

The area lighted was to be about 300,000 square meters (3,200,000 square feet) with about 150,000 carcels (1,500,000 candles) using about 3,000 horse-power. It was intended that the lighting should be done by numerous companies from different countries, but, as a fact, it was done almost exclusively by the larger French companies. It was for this reason that the United States exhibitors were excluded entirely and were compelled to keep their lights within their own floor space, and not contribute them to the general lighting of the buildings and grounds.

There were, in all, nineteen different installations contributing to this lighting—eleven of them were French, three were Belgian, two Swiss, two English, and one German; there were none from the United States. By far the greater proportion of the lighting was from the French companies. The number of lights installed by the

syndicate was as follows: Arc lights, 739 at 8 ampères (1,000 candles), 104 at 25 (3,500 candles), 48 at 60 (10,000 candles), 146 Jablochkoff candles (400 candles), 16 lamps soleil (1,000 candles)—total 1,053 arc lamps. Incandescent lamps: 5,400 at 4 candles, 3,209 at 10, 240 at 16, 154 at 20, 72 at 500—total 9,075 incandescent lamps. This makes in all about 176,037 candles, at a consumption of about 4,000 horse-power. There was, besides this, some gas illumination, but it was small as compared with that from electric lights, except on special fête days, when certain decorative effects were produced for which the number of gas jets amounted probably to hundreds of thousands. A very good summary of the organization and operation of this syndicate will be found in the Memoires de la Société des Ingénieurs Civils, April, 1889, in an article by M. de Bovet, director of the syndicate. Another article regarding this, by Fontaine, will be found in the Bul. Soc. Internationale des Électriciens, February, 1890, No. 65.

LIGHTING OF PARIS.

For the general distribution of electric light and power in Paris the city has been divided into sections, each one of which is given to an electric lighting company who has the exclusive lighting of that section, under conditions, restrictions, and limitations imposed by the municipal authorities. The work is in progress, some stations being already in operation. For a well-illustrated article on this subject see La Lumière Électrique, June 29, 1889.

The great scarcity of electric lighting in Paris, at present, is due to a great extent to the almost prohibitory conditions imposed by the city, in the form of a very high municipal tax on the power which is used for electric-lighting purposes. The reason for this is that electric lighting would otherwise, to a great extent, replace gas lighting, which is in the hands of monopolists holding important privileges, who share their profits in a certain proportion with the city. As their profits are very great under the conditions, the city receives an important revenue from this source, and it would be diminishing this revenue as well as that of the gas companies to allow electric lighting to replace gas. Furthermore, the "octroi," or municipal tax, on coal used within the limits of the city is very high, and electric-lighting companies are not exempt from it as manufacturing companies are. If the electricity is generated outside of the city limits and led into the city an equivalent duty is imposed on the energy used. An authority states that their company has to pay 5 per cent of their receipts (not profits) to the city when the station is inside of the city limits and 7 per cent when it is outside. The charges of one of the companies in Paris are from 21 to 29 cents per kilowatt hour, which is about 16 to 21 cents per horse-power hour of current; the rate in Philadelphia, for instance,

is 7 cents per horse-power hour. For some additional figures regarding this subject see under the heading "Progress" in the Introduction.

STATISTICS.

The Edison Electric Light Company publishes the following statistics regarding their installations. At the close of the year 1888 they had installed in the United States 1,504 isolated plants, having 433,476 lamps; 200 central stations having 675,660 lamps; 23 municipal plants (high-tension series system) having 15,550 lamps. Total, 1,727 plants and 1,124,686 lamps. Their representative states that they have installed 650 miles of underground wire, equivalent to 217 miles of Edison tubing.

The Thomson-Houston Company up to same date had installed 406 arc light central stations having 51,621 lamps, and 170 incandescent central stations having 120,380 lamps; also private plants amounting to more than 20,000 arc lamps and 100,000 incandescent lamps. In 1888 they started to install electric railroads; in one year they had installed 21 lines having 3,000 horse power, and in June had in construction 23 other lines representing 3,000 horse power additional. The Continental Edison Company (French) state that they have installed in France alone 1,500 installations of 100,000 lamps, representing 22,000 horse power.

For some additional statistics see under "Progress" in the Introduction.

ACCESSORIES.

AUTOMATIC REGULATORS.

The regulators exhibited were almost exclusively for automatically varying a resistance in series with the shunt-wound magnets of a dynamo in order to keep the potential of the circuit constant. Compounding the magnets will accomplish this as far as changes in the current strength are concerned, but it will not correct for variations in the speed of the dynamo, which is very important; regulators have for their object to correct for changes in potential no matter what their cause.

In the general type of regulators of this kind there are three essential parts, a resistance arranged in progressively increasing steps, an intermediate mechanism for connecting more or less of this in circuit, and a detector which detects changes of potential and operates this mechanism accordingly. The detector is connected across the mains either at the dynamo or at the center of distribution, according to where it is desired to keep the potential constant. In those exhibited by the Société Suisse pour la Construction de Locomotives et de Machines (Swiss section), and by the Société Alsacienne de

Constructions Mécaniques (French section), which were almost identical, the detector is a solenoid with a movable core; this is attached to a balanced horizontal bar, the other end of which carries a mercury cup which is thereby raised or lowered. Into this dip a series of copper wires of progressively increasing lengths, so that more or less of them will be put in or out of the circuit by the moving mercury cup; these wires lead to the resistances.

In the following regulators the detector magnet operates two contacts, one when the potential is too high, and one when it is too low. The circuits controlled by these two contacts then operate the intermediate mechanism. All these have the fault in common that these contacts require cleaning and care, and at best are very apt to cause trouble.

In the Edison form the mechanism is operated by two magnets which move a common armature lever over a series of sliding contacts representing the resistances.

In the Oerlikon form it is done by a sliding contact moved over the resistance contacts by a long screw shaft. Opposite to the ends of this screw are two magnets whose cores are kept revolving in opposite directions by belts; these magnets are controlled by the detector. A circuit in one or the other causes the screw shaft to be coupled to its core by magnetic attraction; this turns the screw in that direction until the magnet current is broken again by the detector.

The Picou (French Edison Company) form is similar to this, only that the shaft is turned in either direction by a small electric motor controlled by the detector.

The Borssat form is similar to this, only that the shaft is turned very slowly by a worm wheel, and it has on its surface a raised spiral of very great pitch, which touches successively the spring contacts of the resistances.

In the Henrion form, which is identical with the Weston, the sliding contact for the resistances is moved in opposite directions by two ratchet wheels. The pawls for these are kept moving to and fro by a lever operated by a pulley and belt. Two magnets controlled by the detector contacts raise or lower one or the other of these pawls, thereby causing one or the other of the ratchet wheels to be turned. A similar device is used to move the brushes of his series-wound machine to keep the current constant.

The Clerc form, for alternating current machines, is similar in principle to the Edison described above, only that relay magnets are introduced to operate the two large powerful solenoids whose cores move the sliding contact. It is very large and complicated, and is burdened with many details. It is presumably only experimental.

In the Beau & Bertrand form the detector is a short but very

wide magnet, having a large number of small armatures, of progressively increasing weight; these operate the resistance contacts and replace the usual sliding contact. It is large and awkward, but seems to work well.

Among other regulators for various purposes were the following: Lahmeyer regulates for the loss of potential in the leads by means of a small series wound dynamo on the same shaft with the other and connected in the main circuit. It is not apparent what the advantage is over the much more simple compound winding, which does precisely the same thing.

The Dujardin regulator is for putting resistance in the main circuit of a small number of incandescent lamps run from accumulators, to keep the potential at the lamp constant. The detector is an ordinary magnet with a very long contact arm, operating two contacts as usual; the two magnets moving a brush in one direction or the other over a series of resistance contacts, by means of a rachet wheel, pawls, and make and break contacts. He claims to be able to regulate within three-tenths of one per cent. The objection is to the number of contacts which require cleaning and attention.

Reference.—For a voltmeter for measuring the potential at the far end of the leads, without a return wire, see under "Voltmeters."

LIGHTNING ARRESTERS.

The few lightning arresters exhibited for electric-light lines were confined to the American exhibits; there was one in the French section, but it was an acknowledged copy of one of the former. These safety devices, so very common and necessary here, are conspicuous by their almost total absence in the foreign systems exhibited. This is to a great extent due to the fact that the lines are mostly underground, and are carefully kept free from grounds; also that high potential circuits are comparatively rare; also that such violent electric storms as we have are much less common on the continent. Another explanation of the absence of lightning protectors is that many systems there are not as completely equipped as they should be.

Thomson-Houston.—Among the most prominent lightning arresters were those exhibited by the Thomson-Houston Company. Those for continuous current circuits, though no longer new, are perhaps not well known.

The principle of all of them is that the lightning is led to earth by jumping across a small air space, and that the arc which is formed thereby, and which might be continued by the dynamo current, is blown out magnetically by means of a magnetic field produced by an an electro-magnet.

There are a number of different patterns, depending on whether they are for arc, for incandescent, for railroad, or alternating cur-

rent circuits. In all of them the arc is formed between two metallic plates in the same plane, one connected to line and the other to earth; their adjacent edges, where the arc jumps over, are close together at one point, being separated only by an air space of one-sixteenth of an inch, and are far apart at the other; the magnetic field produced by the two poles of a U-shaped electro-magnet, which are situated on the two sides of this space, repels or blows this arc from the short toward the long air space, thus gradually increasing the length of the arc, which weakens it and finally extinguishes it.

In some (those for arc-light circuits) this electro-magnet is always in the main circuit, and is connected between the machine and the arrester, so that its self-induction helps to protect the machine. In others (for incandescent light and railroad circuits) the current for the electro-magnet is that of the arc itself, the magnet being connected between the ground plate and the ground; in this form the magnet circuit is shunted by a small air space between the two points, across which an excess of the lightning may pass.

For alternating currents the magnet, which is always in circuit, is ingeniously arranged; it is connected between the machine and the line and is wound bifilar, like a resistance coil (that is, with two equal windings in opposite direction), so as to have no self-induction and develop no magnetism under normal conditions. The "bight" or junction of these two opposing windings is connected to one of the plates of the arrester, the other being led to earth. When lightning strikes the line it passes through *only one* of these two windings, and hence through the plates to ground; this develops magnetism which blows out the arc. In addition to this there are points and plates separated by small air spaces, which shunt the coil and take the excess of the lightning current. To assist in blowing out the arc, a knife edge of slate is sometimes introduced in the air space between the plates, as if to cut the arc. In those for alternating currents the space in which the arc is formed is carefully insulated from all the rest of the apparatus by means of thick pieces of slate. The writer witnessed the experiment of short circuiting a 3,000-volt arc-light machine through one of the arc-light current arresters; the powerful arc formed was instantly blown out, accompanied by a loud report.

The Electrical Supply Company exhibited a lightning arrester, the principle of which was that the lightning passed between the usual plates, with saw teeth, to the ground, and in doing so it passed through a magnet which tripped a lever, which, by means of a simple drop mechanism, rapidly separated these two plates so as to extinguish the arc which might otherwise be continued by the line current.

A system which is said to be used in Switzerland, but was not exhibited, consists in introducing into the circuit a "choking" or self-induction coil between the machine and line. The machine end

of this coil is connected to a condenser, the other plate of which is grounded. The other end of the coil is connected to the usual saw-teeth lightning plates, one of which is grounded. The choking coil protects the dynamo by its self-induction. The fault of this apparatus is that it does not extinguish the arc should it be continued by the dynamo current through a second ground.

AUTOMATIC SAFETY CUT-OUTS AND FUSES.

Among the numerous exhibits in this class there was little of novelty, though some were of interest. The features desired in lead fuses, judging from the exhibits, appear to be to facilitate replacement, to make a burnt fuse render itself readily visible, and to guard against the scattering of the hot metal. There were exhibited a few electro-magnetic cut-outs, but they do not seem to meet with much favor, probably on account of their cost. There was only one high potential cut-out, that of Thomson.

Lead fuse cut-outs.—The fuse exhibited by Postel-Viney (French section) consists of a short glass tube with a copper cap at each end, the lead wire being in the interior, with its ends fused to the copper caps. The holder consists of two large screws, between the ends of which this tube is clamped axially at the caps. When a fuse is blown the tube becomes white inside, which enables it to be detected readily. The tube prevents the scattering of the metal.

The fuse on the Zippernowski transformer is similar to this one, only that it is attached to a wooden handle perpendicular to it, and the contacts are made in the form of spring clamps. The object is to enable a fuse to be replaced without having to touch the circuit.

In the Cockburn fuse exhibited by the Acme Electric Works (British section) the wire is long and horizontal, with a small weight attached to its middle point, which is intended to break the wire before it fuses.

In the Hedge fuse exhibited by the Globe Electrical Works (British section) there are two separate fuses in series, with a convenient short-circuiting switch by which either one may be short-circuited. Either one of them should always be short-circuited. When the one in use is blown the switch may be moved over to short-circuit its terminals, thus putting the other one in circuit. The blown fuse may then be replaced at leisure. The fuses themselves, as is well known, consist of a strip of tin foil between the two pieces of mica, which cover it completely.

Among the fuses in the Edison exhibit was one in which there were a number of independent fuses, with a switch enabling a new one to be switched into circuit very rapidly, giving time to replace the burnt one. These successive fuses may also, if desired, be made of increasing sizes for special purposes, the smallest one being normally

in circuit. Their fuses for the municipal system (high potential) are made of a long lead wire wound spirally around a glass tube or slate block to prevent the formation of an arc.

Magnetic fuses.—Among these was one of Woodhouse & Rawson's, in which an electro-magnet in the line circuit attracts a weighted armature pivoted like an inverted pendulum. The moving of this armature ruptures the circuit by lifting out the bridge piece of two mercury cups. By the latter device sliding contacts at the movable armature are avoided. In another, for very large currents, exhibited by the Société Alsacienne de Constructions Mécaniques, the magnet trips a small light lever, which in turn trips a large heavy lever, which opens a snap switch by the action of a strong spring.

High potential safety device.—In the Thomson-Houston exhibit there was a switch consisting of a knob at the end of a flat spring which pressed it against a contact piece. A piece of paper pinched between the two insulates them from each other. The two parts are connected to the two mains or leads which are to be protected against a great increase of potential; when the potential becomes too high it pierces the paper, making contact between the two leads, thereby short-circuiting them. It is used on arc lamps in series to cut out the lamp should the circuit be open in the lamp. It is also used in the alternating current system, in which each of the secondary or house mains is connected to earth through such a cut-out. Should the potential of either one of them become too high, by a cross with the primaries, or by lightning, it will immediately be grounded, thus rendering it perfectly safe.

SWITCHES.

Among the necessarily very large number of switches exhibited there were but few that are of sufficient interest to be mentioned here. Small switches are as a rule so simple and so easy to design that there is little of interest to be described. For small currents it has become almost universal practice to use the so-called "snap switches"—that is, those which open with a snapping movement and have only two stable positions, either entirely open or entirely closed. Most others have gone almost entirely out of use. It is also becoming more general to use the double-contact switches, in which the circuit is broken twice. This may be due to the fact that it often simplifies the construction. Double-pole switches were rare. Porcelain and other similar substances* are coming into use more and more for small switches.

Switches for strong currents are much more difficult to design, requiring much more care in their designing than is often given them. The greater number of those exhibited were not well designed,

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*See also "General supplies."

so far as the contacts were concerned. The mere fact of having large surfaces and masses of copper does not necessarily mean that the contacts are good. They may keep cool, but this may be due to the large masses of good heat-conducting copper. Such switches may do their work, but they do not do credit to their designers. A switch must be exceedingly poor to fail completely. The contacts in many were examined carefully and were found to be very poor as compared to the size of the intended surfaces of contact. The bright parts of these surfaces are not necessarily indications of the size of the true contact, as they may be simply scratches from a mere line or point contact, Even some of the better companies had very poor types of switches. One of the large well known French companies even had a type of switch which could hardly have been designed worse: two rigid flat horizontal surfaces, one *laid* on top of the other. There was absolutely no sliding or friction, and no flexibility of the surfaces, a grain of dust would destroy the contact almost entirely,

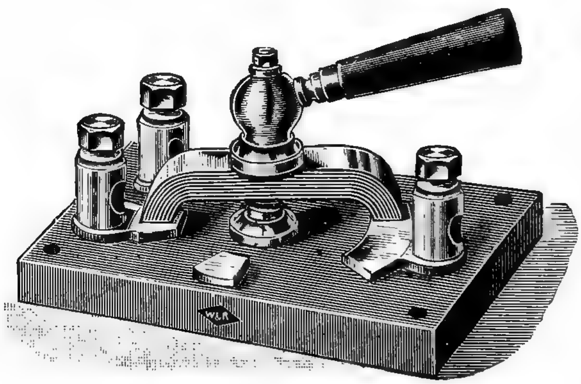


FIG. 8.—Two-way switch; by Woodhouse & Rawson.

if not quite so, and the spark on opening completely destroys the contact surfaces.

The requirements of a good switch are, that the surfaces should be self-cleaning, that one of the two contact surfaces must be of a flexible yielding nature to adapt itself to the other, and that the spark on opening should take place at such parts of the switch which, if burnt, do not affect the contacts. A switch on the same principle as the contact of a commutator brush of a dynamo answers all these conditions. There were several such switches exhibited. When designed in this way, a small switch will carry a much larger current.

Switches of the class just described were exhibited by Woodhouse & Rawson, Crompton, Société Alsacienne de Construction Mécanique, Iliyne-Berline, Hedge, and Augé. Some of those of Woodhouse & Rawson are shown in the three adjoining cuts; the first, Fig. 8, is a two-way switch, the second, Fig. 9, and third, Fig. 10,

are snap switches. The movable contact in all of these is made of a large number of fine strips of spring copper, each of which adjusts itself to touch along the whole length of its edge; the total surface of contact is then equal to the total cross section of the arm. At the ends these strips should be slightly separated from each other so as to allow for a slight play to adjust themselves.

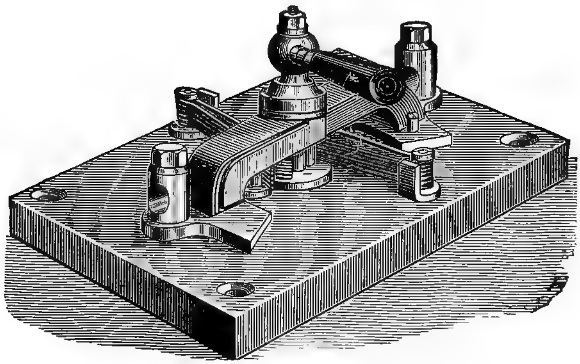


FIG. 9.—Snap switch; by Woodhouse & Rawson.

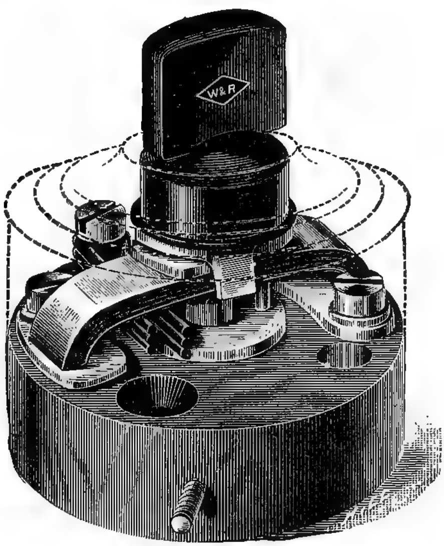


FIG. 10.—Snap switch; by Woodhouse & Rawson.

Almost all the others are similar in principle but differ in construction. In one of them (Crompton) there is, in addition, a small replaceable spring fastened on one side of the contact springs, which takes the spark and thereby prevents the others from being burnt.

In those of the Alsacienne Company the upper foil was too stiff to adjust itself, many of the springs touching in a point only instead of a line.

In those of Iliyne-Berline the foils were bent, somewhat like the letter S, and were in planes parallel to the axis instead of perpendicular, as in the others, rubbing on the inside of a cylindrical surface. This has the advantage that the springs will not wear grooves in the solid surface; it has the disadvantages that the snapping of the springs on opening make a great noise, and that it can be turned one way only.

In the Hedge form both surfaces are flat, but the movable one is connected with the lever by a flexible connection, thereby allowing it to adjust itself to the other surface. An interesting and ingenious feature of all the switches, cut-outs, etc., of Hedge's is that all screws which may have to be used in making the connections have a high projecting head with a deep, wide cut; the object of this is to enable any ordinary coin to be used in place of a screw-driver; a screw-driver is not always at hand, but a coin generally is.

In many of the large, as also in small switches of various types, it was noticed that the hinge or pivot of the movable lever is rarely used as one of the contacts; the lever is preferably made so as to break two contacts, in which case the hinge is not in the circuit.

The Oerlikon circuit breaker is intended for opening circuits of several hundred ampères and several hundred volts, such as those used in their transmission of power. For such currents an ordinary switch will evidently not answer. In this cut-out there are two contacts in multiple arc; one is a good metallic contact made by a large carbon rod forced in between two spring sockets, and connected by a flexible lead. To open the circuit, the metallic contact is first opened by lifting the carbon out of its seat; this throws all the current through the carbon contact, which is then broken by pulling it out of its socket. All of the spark, which is very large, is therefore taken by the carbon and not by the switch proper.

COUPLINGS FOR WIRES.

There were three different couplings for line wires exhibited, one French and two American.

The former, exhibited by Lapointe, is for fine wires only. It consists of two copper tubes, one with a male screw thread on the end and the other with a female screw. The ends to be spliced are each threaded through both tubes and passed through a lateral hole at the end of the farther tube. The two tubes are then screwed together, which twists the wire together. It forms a strong joint and is easily made, but the contact is not necessarily much better, if as good, as the usual twisted splice.

The McIntyre coupling (United States section) is well known here. It consists of two tubes soldered together so as to have a cross section like a figure 8. The ends of the wires are passed, one into each of these tubes and from alternate ends, the whole being then twisted;

the flattening of the tubes caused thereby makes contact with the surface of the wire, while the twist gives the splice mechanical strength. The objection is that the tubes, which are moderately long, especially for thick wires, must fit the wire closely, and it is not always easy or simple, especially on top of a pole, to straighten such long ends of the wire so that they will go in. For thick wires, as for arc-light circuits, it requires two special tools and two men to twist the coupling.

The Hering coupling exhibited by the Electrical Supply Company (United States section) and known as the "vise grip" coupling, consists of two short split tubes which fit the wire moderately closely, and which are connected together parallel to each other by two flat pieces; after the wires are inserted these flat pieces are bent, by a blow of the hammer, so as to bring the tubes together; the construction is such that this causes the tubes to close on to the wire like the grip of the hand, with a very great force, which is sufficient even to stretch the copper tubes. The contact is therefore around the whole surface of the wire, and is therefore very large and good. The time required is very much less than that for an ordinary twist coupling. The length of wire used is less than one-half of that required for the usual splice.

BINDING POSTS.

Among the binding posts exhibited were several of interest. The one exhibited by Woodhouse & Rawson, shown in Fig. 11, consists of a slotted bolt and nut; the wire to be clamped is placed through the slot; it has a number of obvious advantages. A very good spring clamp binding post exhibited by Camus (French section) is shown in Fig. 12. The cap is capable of being lifted up slightly, being held down by the spring; the wire is placed under its edge or through the hole in the pin, the spring cap holding it there securely. Its use is limited to temporary connections such as with instruments, for instance, for which purpose it is very convenient.

FIG. 11.—Binding post; by Woodhouse & Rawson.

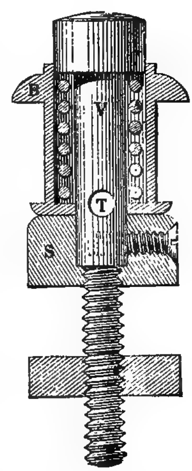


FIG. 12.—Binding post; by Camus, France.

The following simple and very good binding post was quite common, particularly on French machinery. It is for connecting stranded cables for strong currents to dynamos, switch boards, etc. It consists of a short semicylindrical block, which rests with its curved surface in a corresponding grooved block, which forms the base; two bolts, passing transversely through it, enable it to be clamped down into this groove. The stranded end of

the cable, slightly flattened, is passed between this semicylindrical piece and its grooved seat, and is then secured there by tightening the bolts. By virtue of the slight bending and spreading out of the strands, all, or almost all, of the strands are brought into contact with each other or with the clamp. An illustration of it may be found in the recording ampèremeter (Fig. 59), under "Instruments." It replaces the solid eye piece which is generally used with stranded cables, but which requires to be soldered to the cable, and is therefore not so convenient, although neater.

MISCELLANEOUS ACCESSORIES.

Choking coil.—In the Thomson exhibit (United States section) was shown an induction or "choking" coil, by which the amount of apparent self-induction could readily be varied at pleasure. It is for use with alternating currents just as an adjustable resistance is used with continuous currents, and like these it absorbs energy, and its use is therefore limited in practice. Its chief advantage is its

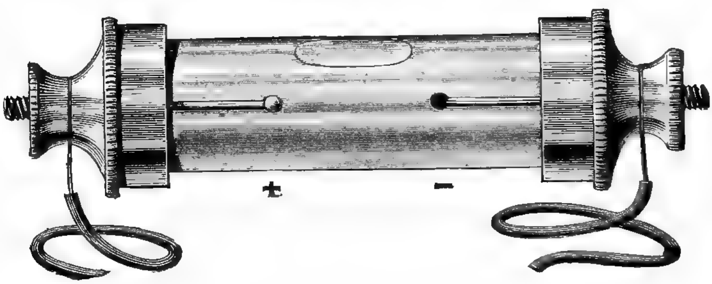


FIG. 13.—Pole indicator; by Woodhouse & Rawson.

convenience and the absence of all contacts. It may be described as resembling a Gramme ring, with a single coil, covering about one-third of the ring; this is the induction coil. Another third of the ring is encircled by a single short-circuited coil, made of solid thick pieces of copper; this fits very loosely, and is capable of being moved about the axis of the ring as a center, by means of a handle, so that it can be moved over any portion of the ring or the induction coil; lastly, the open space in the ring is filled with round iron disks. When the two coils are on opposite sides there is practically no induction in the solid copper coil, as it is magnetically shielded by the iron disks. As it is moved over the other, currents will be induced in it, which will be a maximum when it completely covers the induction coil, in which position the apparatus is a true transformer, with a short-circuited secondary. This variable induction in the secondary will generate a variable counter-electromotive force in the

primary, by which any required apparent self-induction can be obtained.

Pole indicator.—Woodhouse & Rawson, Danzer, and others exhibited a pole indicator, by which the polarity of a circuit can readily be found. It consists, as shown in Fig. 13, of a glass tube containing a liquid and two platinum terminals. If these are connected to the two poles of a dynamo or a circuit, the one connected to the negative pole will turn a pink color. Its resistance is given as 30,000 ohms. It can, therefore, be used for high potential circuits. It is said never to require a change of the liquid.

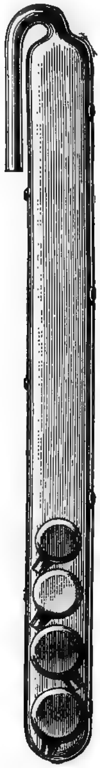


Fig. 14.—Hicks' hydrometer, for accumulators.

Accumulator hydrometer.—The Hicks hydrometer, shown in the adjoining cut (Fig. 14), exhibited by Woodhouse & Rawson, is to replace the usual hydrometers for accumulators. It consists of a flat glass tube, perforated with small holes, and containing four little glass globules of different colors, each of which will rise or fall for a distinct specific gravity. It is arranged to hang over the edge of the cell, by means of the hook at the top.

Wire straightener.—The adjoining cut (Fig. 15) shows a very convenient and probably very effective wire straightener, for use in winding magnets, especially for large, thick wires. It was exhibited by Woodhouse & Rawson. The wire passes through axially and on alternate sides of the rollers, which are adjustable. Besides the straightening effect of the rollers themselves, the whole frame is made to revolve, having therefore the effect of many rollers in different planes.

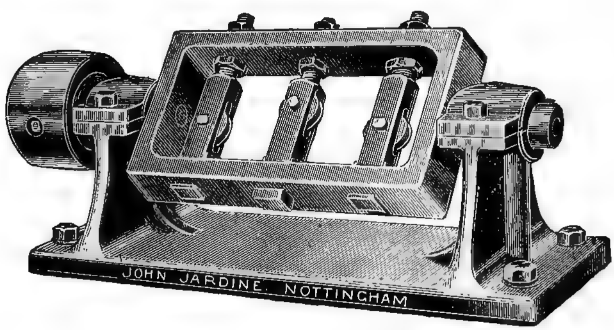


Fig. 15.—Wire straightener; by Woodhouse & Rawson.

Driving-gear for dynamos.—See "Dynamo accessories."

MISCELLANEOUS APPLICATIONS OF ELECTRICAL ENERGY.

Under this heading will be mentioned only those applications in which the more powerful currents are required, as distinguished from the many applications of a lighter character which belong more properly to the same class as electric bells, annunciation, gas ignition, etc., which see for other miscellaneous applications. Electro-metallurgical applications of electricity are not included in this report, as they belong more properly to the department of Mining and Metallurgy.

ELECTRIC WELDING.

There were two exhibits of electric welding, one, the Thomson process, by directing heating, and the other the Bernados process, sometimes called the Russian process, by means of the electric arc.

Thomson's process.—The Thomson process was invented within the last few years by Prof. Elihu Thomson of Boston. The exhibit of this process in operation (United States section) was exceedingly interesting and attracted probably more attention among both technical persons and the general public than any one other electrical exhibit.

Electric welding is one of the very few recent developments of an important character in an entirely new direction. The exhibit was very complete, including a number of different machines for different purposes. They were designed in all their details in as complete and practical form as possible, a characteristic feature of many of the American exhibits.

The principle is, that the two ends to be welded are brought together, and a powerful current passed through the contact at their junction; owing to the resistance of this imperfect contact, the metal is heated very rapidly at this point and in its immediate vicinity until a welding heat is reached, when the pieces may be pressed together slightly. The welds are necessarily always "butt" welds. The cooling action of the clamps, and the fact that the high resistance due to the high temperature keeps generating more heat there, both tend to keep the heat confined to the immediate vicinity of the joint.

The machines, in general, consist of two clamps of copper for holding the pieces and for conducting the current to and from them; one of them may be moved parallel to itself by a lever or other device. These clamps with the pieces to be welded form part of a large transformer, of which they are a part of the secondary coil which has only a single winding, consisting of a large bar of copper; the contact at the weld forms a short circuit to this coil.

In all of the machines the current was started, broken, or regulated by switches and resistances in the primary circuit of the trans-

former, or in the exciting current of the dynamo, thereby avoiding the use of all switches, etc., in the low-resistance circuit of the welding current.

There were four machines exhibited; the large one, for iron bars from 1 to 2 inches in diameter, consisted essentially of a large transformer, a separate alternating-current dynamo, and an exciter for that dynamo, the exciting current being controlled and regulated by the operator at the welding machine.

The second one, for ½ to 1 inch iron bars, consisted merely of a transformer, and is intended to be used when the current can be taken from the general mains of a system of alternate-current distribution, in place of using a dynamo and steam power.

The third one, called the direct welder, for ⅛ to ½ inch iron bars, is for use with power direct, and consists essentially of a small dynamo with an armature similar to the old Siemens H armatures, having two windings, a very coarse one in which the alternating current was not redressed, and which was connected directly to the clamps, and the other a small one in which the current was redressed and formed the exciting current for the field. The dynamo was situated immediately under the working table, thereby reducing the length of the leads for the welding current as much as possible.

The fourth was a small automatic welder for copper wire from Nos. 6 to 19 B. & S. It was arranged to automatically open the circuit when the weld was finished, that is, as soon as the softening of the metal permitted the clamp to move forward a slight distance. It was arranged with a small transformer, and was especially adapted for small chains and similar work. The current was regulated by a "choking" coil (see "Accessories"). Many of the details that can not be included in this short description are very ingenious and are arranged very practically to make the operation as simple and rapid as possible.

Among the chief advantages claimed are the great simplicity and rapidity of the operation, the perfect nature and reliability of the weld, the clean form of the weld requiring little dressing afterwards, its application to short pieces and in general where other methods fail; also its use for welding metals that could not be welded by the ordinary methods, replacing therefore the usual soldering.

The exhibit included welds of the following metals: Gold, platinum, silver, copper, aluminium, bismuth, cobalt, nickel, antimony, zinc, tin, lead, wrought iron, cast iron, magnesium, German silver, brass, and steel; also welds of nickel with iron, iron with steel, gold with silver, platinum with gold, brass with copper, iron with brass, German silver with iron, brass with German silver, German silver with copper, also lead with other metals.

Applications.—Among the uses to which it is already applied in

practice are the following: In chain welding, in steel tube welding, in wire-drawing establishments, for joining hauling cables, for carriage fittings of all kinds, for pipe welding up to 5 inches in diameter, in making homogeneous tubes for ice machines, in pipe bending, for making springs, for joining bands for bales and boxes, for splicing band saws, for making carpenter's and machinist's try squares, etc. It is also used for raising a collar or shoulder on a bar of iron by heating it in the welder and, while hot, compressing the bar lengthwise to enlarge the diameter.

A machine is also being constructed for riveting, in which the two clamps are replaced by two heavy pieces of copper with conical holes, facing each other; the rivet becomes heated at its ends where it touches these two holes, the large size of these metallic pieces preventing them from becoming so hot as to become welded to the rivets.

Power consumed.—The following table gives some data regarding the power required for the welds, also some deductions made therefrom by the writer, which may be of interest. The welds were made with wrought-iron bars of different diameters; the energy was that delivered to the primary coil of the transformer; the current and potential are those at the weld; the former was measured at the weld and the latter was calculated from the energy in the primary coil, allowing about 90 per cent efficiency for the conversion.

Diameter of wrought iron bar.	Kilowatts in the primary.	Time.	Units of heat consumed.	Potential at the weld.	Current through the weld.
Inches.		*Secs.*		*Volts.*	*Ampères.*
2	61.6	50	2,900	2.06	27,000
2	52.5	58	2,900	1.98	24,000
2	31.2	144	4,300	1.74	16,000
1	13.0	43	530	1.51	7,750
1	12.4	44	520	1.74	6,400
¾	7.8	33	250	1.46	4,800
¾	7.5	35	250	1.52	4,500
½	4.1	18	70	1.16	3,200
½	3.5	21	70	1.12	2,800

Strength of the weld.—In the opinion of the writer too much stress is often put on the fact that there is often a loss of tensile strength at the weld, as the most important advantages of electric welding are thereby overlooked. The chief advantages of electric welding are given above, and the strength of the weld is in most of cases of small importance as compared with the other advantages. At the same time official tests show that the tensile strength per square inch is in many cases not reduced very much, and that what loss there is is due in many cases to the fact that the metal has been heated, and not to imperfections in the weld; without heating, a weld can not be made.

A proper comparison, therefore, would be between a weld and a similar bar which has been heated. Such a comparison can be reduced from the official tests made at the Watertown Arsenal, which are included in a paper on electric welding by Woodbury in the transaction of the American Society of Mechanical Engineers, Vol. x, No. cccxv. By comparing proper samples in these tables it will be seen that wrought iron, copper, and brass bars have practically the same tensile strength per square inch before and after the weld, the bars (except the copper) which were not welded having been heated.

The weld can evidently be made stronger than the rest of the bar if it is slightly enlarged at the weld, which in many cases, as in chains, for instance, is not an objection. Prof. Dolbear states: "I had a number of bars welded by an expert blacksmith and a number of similar ones by the electrical process for comparison, with the results that the electrically welded bars were much stronger than those welded by the ordinary process. The bars were of various sizes, up to an inch and a half for iron and three-fourths of an inch octagon steel."

Bernados process.—The Bernados process of welding by the electric arc was exhibited by the Société Anonyme pour le Travail des Métaux (French section). The current was obtained from a large battery of accumulators, of 75 volts and 200 ampères. The carbon rod held in the hand is connected to the positive pole, and an iron table on which the welding takes place is the negative pole. The carbon is about half an inch in diameter, and is provided with a suitable handle, a flexible lead, and a heat shield to protect the hand; the operator uses a blue-glass screen. The arc is very long, and the process occupies considerably longer time than the Thomson process. The writer found that it took from 3 to 5 minutes to make a weld of a piece of iron $\frac{1}{4}$ by $1\frac{1}{4}$ inch. The joint must be hammered, as in a smith's weld. As the metal is burnt and brittle where it is welded, the process is not a success. Its only commercial application at present is to weld nickel tubes to iron ones, for the tubes used in glass-blowing.

APPLICATIONS OF POWER.

Bon & Lustrement (French section) operated one of the two traveling cranes in Machinery Hall by means of an electric motor. The single motor and generator were both series machines; the former turned always in one direction. The three operations of moving the crane bodily on its track, of moving the lifting mechanism on the crane, and of raising the weight, were all done by means of conical and cylindrical friction wheels; the reversing and changing of speed were all done mechanically, the motor being run continually at a constant speed and in the same direction. The mechanism required to do this was therefore much more complicated

than if it had been done electrically, as with the motors on an electric railway. The current was taken from two bare wires immediately alongside of the track.

Megy, Echeverria & Bazan (French section, silver medal) operated the other traveling crane. It was quite similar to the first only that a different kind of friction clutch was used.

Chrétien (French section, silver medal) exhibited an elevator driven by electric motors. The electrical system was, as in most of these power transmissions exhibited, a simple series system with series wound motors. There were two motors in series driving the rope drums by means of worm wheels. The leads pass through the elevator shaft as four bare strips against which slide the brushes of the car, which contains the switch and the resistance for starting. One of these strips is in some places broken into a number of short pieces which are connected by resistances which are put into circuit automatically by the car as it passes this point. These are located just before the stopping places, so as to stop the motor gradually. The motors turn in two directions and have a mechanical device for shifting the brushes on reversing. There is a weighted brake on each motor shaft held off by an electro-magnet in the main circuit. The brake is therefore automatically applied as soon as the current is stopped, intentionally or accidentally.

Sperry (United States section) exhibited a horizontal mining drill operated by an electro-motor. The drill moves axially and strikes with a blow. The essential feature is that the motor merely pulls the drill back against the action of a strong spring and then releases it, thereby allowing it to strike with a sharp blow. The blows are in very rapid succession. The motor is an ordinary rotary one, the reciprocating motion being produced by gearing and a pawl. The whole is balanced on two low wheels. For an illustration see Electrical World, June 15, 1889.

Hillairet (French section) exhibited a mining drill, of the rotary type, which was connected directly to the shaft of the motor as a continuation of it, the motor being supported by a toggle joint in a tripod.

Renard (French section) exhibited a motor as applied to propelling the great military balloon "La France." It was intended to be run by batteries. The arrangement exhibited was an experimental apparatus to measure the turning force and the axial thrust of the fan-shaped air propeller. The whole mechanism was supported so that these forces could be balanced by weights on lever arms and thereby measured. For a description of the primary battery, see under that heading.

Trouvé exhibited, among many other applications, a small boat (not in operation) driven by an electric motor from bichromate batteries. The peculiar feature is that the motor was secured to the

top of the rudder and was geared directly to the propeller by chain gearing, the propeller being also in the rudder itself. It is not clear what special advantages this is intended to have, except in turning. With a motor having two armatures 6 inches long, he obtained a speed of 6 knots an hour. He experimented with electrical navigation on the Seine as early as 1881. No figures of importance could be obtained from the attendant of the exhibit, but as a primary battery of the well-known forms was used, the quantity of power carried could not be very great, and would necessarily be very expensive on account of the materials consumed. For some additional remarks see "Primary Batteries."

Deprez (French section) exhibited a number of applications of electrical power. One was in the form of a drop hammer in which a coil around the hammer shaft was intended to lift the hammer by the magnetic action of drawing it into the coil. It was not in operation. A crane attached to the hammer to hold the material was also operated electrically. All switches were controlled by one operator at the hammer. Another application was a sort of revolving capstan having a motor underneath it to turn it. It is used by some of the French railroad companies for drawing cars over short distances in drilling a train, where horses were formerly employed.

Guyenet (French section) exhibited a traveling crane and a windlass, designed for use chiefly in storehouses. The electric motor was pivoted so as to be movable slightly parallel to its shaft. One end of the shaft was a small cylindrical friction pulley which drove a large double-rimmed pulley in one direction or the other according as it was pressed on to the inside surface of the annular rim or on the outside surface of the other rim; this was effected by moving the whole dynamo by a conveniently arranged lever. The whole was very practically arranged, but leaves little to be described from an electrical point of view.

Sautter, Lemonnier & Co. exhibited a complete outfit of an engine, dynamo, and projector, which is used on the vessels passing through the Suez Canal. The engine and dynamo are together on the same base plate, and can be installed on a steamer in 40 minutes. A local company rents these outfits at £10 for one passage. It is stated that 72 per cent of the vessels pass at night, with the electric light, in 18 hours. The authorities are said to require every vessel that passes at night, to carry an electric light or projector enabling them to see a distance ahead of at least 1,200 meters (about 4,000 feet).

MAGNETIC SEPARATORS OR SORTERS.

The object of these machines is to separate particles of iron or other magnetic matter from any non-magnetic matter with which they are mixed. They are used largely in the arts, chiefly for the following purposes: In mining and metallurgy for the separation of

the mineral magnetite or magnetic iron ore from its accompanying minerals; in machine shops and foundries, to extract the iron from filings, turnings, and chippings (an operation which is often done by hand, but which is very injurious to the health of the workman on account of the fine copper and brass dust); in flour mills to extract fragments of iron from the grain; in the manufacture of white zinc oxide, to extract magnetic impurities; in numerous industries, to extract pieces of iron from crude materials to which they have been fraudulently added to increase the weight.

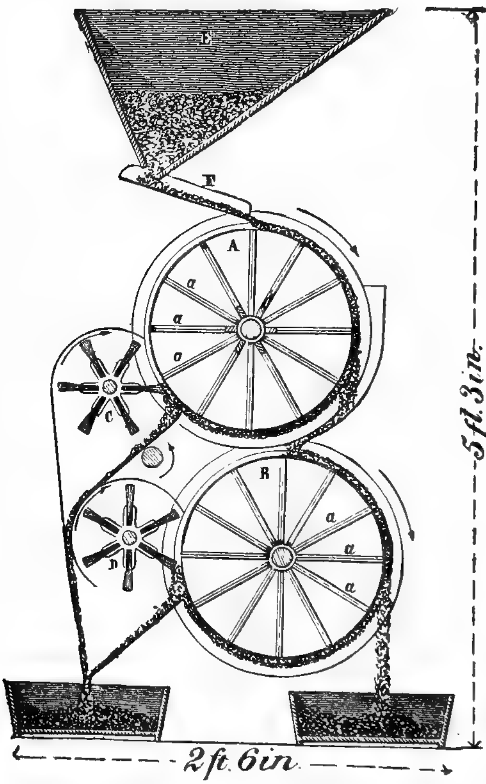


FIG. 16.—Magnetic separating machine; by Vavin, France.

The general principle of all these machines is that the material in the form of sand, powder, or small particles, is made to pass over or near powerful magnets which attract the iron particles or the magnetic iron ore, and allow all the other materials to pass by, thus affording a very good, simple, and reliable means of effecting a separation.

There were three of these machines exhibited, one each from France, the United States, and Belgium, differing only in the manner in which this principle was applied.

Charles Vavin (French section, bronze medal) exhibited the machine shown in the adjoining cut, Fig. 16. The material falls on the two drums, as shown. Each drum is made of four wheels; the spokes, *a a*, of these wheels are permanent magnets, having their like poles at the circumference, and there connected in common to an iron ring, which, therefore, forms one of the magnetic poles on the surface of the drum. The four wheels, making one drum, are alternately of north and of south polarity, forming, therefore, strong magnetic fields all over the surface of the drums. The material falls, as shown, over these drums revolving at the rate of thirty-two revolutions per minute; that which is magnetic attaches itself to these drums and is brushed off by the revolving brushes C and D. The object of two drums is to repeat the operation to make the separation more thorough. This is probably necessitated by the fact that permanent magnets are at their best not very strong.

Its working capacity is said to be 660 pounds per hour; it requires one-sixteenth of a horse power, and can be turned by hand. There are over five hundred of them in use. It has the great advantage over the others in that no battery or dynamo is required to generate the magnetism, as the magnets are permanent. It appears to be used chiefly in machine shops.

The Edison sorter consists simply of a hopper and a huge electro-magnet. The material falls continuously, in form of a sheet, from a long, narrow slot in the bottom of the hopper, and in its fall it passes by and near to the pole of the large magnet, but does not touch it; that material which is not magnetic falls perfectly vertically, while that which is magnetic is attracted toward the magnet and is thereby deflected from its vertical course, falling on the other side of a partition which separates it from that which falls vertically. The advantages are that the process is very rapid and requires no power except the current for the magnet. The disadvantages are that a battery or a dynamo is required and that only a certain class of material, such as sand, can be made to fall in front of the magnet in the form of a thin sheet. Probably for this reason it appears to be used chiefly in mining, for separating the magnetic iron ore from its accompanying minerals. It is claimed that black sand, found in so many places, as well as other iron ores which are too poor to be worked by other methods, can be worked to great advantage by this machine.

In Jasper's sorter, exhibited by Eschger, Ghesquière & Co. (Belgian section), the object seems to be to obtain an exceedingly intense magnetic force, and it appears to be used chiefly in the manufacture of zinc and zinc oxide. It consists of two iron horizontal rollers, side by side and almost touching each other, somewhat resembling crushing rollers. The ends of these rollers, next to their bearings, pass through fixed coils of wire through which a current is

passed, which magnetizes them so that the one roller is a north pole at the exposed portion between the coils, and the other is a south pole. The narrow space between them is, therefore, an exceedingly intense field. The material is made to pass between these rollers at this place, the rollers turning in the opposite direction to that in which they would turn if they were intended to crush the material. The magnetic particles, therefore, attach themselves to these rollers, are carried out over the rollers and scraped off by means of scrapers, while the non-magnetic material falls through the space between the rollers. As the bearings must necessarily be magnetized by this disposition of parts, there will doubtless be considerable friction produced. Its capacity is stated to be 4,400 pounds per hour, and it requires 2 horse power.

ILLUMINATED FOUNTAINS.

The most effective decorative display of electric lighting and its advantage over other lighting was shown in the very attractive illuminated fountains on the exhibition grounds. They were not only the chief and very effective attraction in the evenings for the general public, but were of considerable interest from a technical point of view.

The finest part of the fountain was the same that was used in the Glasgow exhibition of 1888, and known as the Galloway fountain (English section, gold medal). As it has been described in the technical journals it is not necessary to give a detailed description here.

The principle of the illumination is that a powerful beam of light is passed vertically upward through a hole in the top of a tunnel under the fountain, the hole being covered by a glass plate above the water level. Above this plate the jets are arranged so that the water passes up through this beam and remains entirely within the vertical conical space illuminated by the beam; it thereby becomes highly illuminated, while the beam of light itself is quite invisible, the glass plate and jets being hidden from view by some decorations around them.

The effect is exceedingly striking and beautiful. Glass plates of different colors were moved into the beam below the jets, thereby coloring the light; all these, as also the valves for playing the jets, were under the complete control of the operator and were controlled with the greatest facility; the lights are powerful 60-ampere arc lamps with reflectors or lenses or both, to give the rays of the beam the proper direction. There were thirty-three of them, which, together with fourteen others, required 300 horse power. They were all hand regulators.

Another system was also tried, but it was not a success; it was intended to be an application of the well-known physical experi-

ment of internal illumination of a clear jet of water issuing horizontally. Although the jet was illuminated it was so only for a short distance, when the light was dispersed. The same was tried at the Philadelphia Electrical Exhibition in 1884, but was abandoned as unsuccessful. An illustrated description of this Paris fountain will be found in the Electrical World, June 15, 1889.

II.—TELEGRAPHY AND TELEPHONY.

TELEGRAPHY.

GENERAL.

With the exception of a few exhibits, there was comparatively little of special interest as a novelty or an important departure in a new direction. The exhibits showed little more than the natural progress of an already well studied and well developed industry. The progress shown was almost entirely in details and in the gradual development of existing systems and apparatus, rather than in the introduction of entirely new ones. Telegraphy has already reached such a high degree of perfection and development that further progress is necessarily slow.

Among the new departures from the usual systems may be mentioned the telautograph of Gray, for reproducing the movements of a pencil; the steno-telegraph of Cassagnes, which is based on stenography; the train telegraphy of Edison, based on static induction, and an attempt at telephonography by Lambrigot. If some of these should develop into important systems they would be more likely to create new fields for telegraphy than to replace the present systems.

Among the more important recent developments of existing systems may be mentioned the Wheatstone automatic system, the duplexing and quadruplexing of the more complicated systems, the Baudot multiplex, and some harmonic systems. Of these, probably the most important is the Wheatstone automatic, which has now been increased to six hundred words per minute, which is from three to four times as fast as one can speak or transmit through a telephone. It is duplexed up to four hundred words, and is therefore a formidable opponent to the multiplex systems.

The telephone, as a sounder, is coming into use more and more in numerous systems.

In the city of Paris itself messages are sent almost entirely by the pneumatic-tube system, in preference to electrical transmission. The former presents many advantages besides being very cheap and

avoiding errors, as the original written message itself is sent. In London this system is also in use, in connection with the main telegraph office, to collect and distribute the telegraphic messages in the central part of the city.

Exhibits by countries.—With a very few exceptions, the exhibits in telegraphy were entirely from France, and were mainly in the large collective exhibit of the Post and Telegraph Department of France. England and the United States were the only other countries having exhibits of any importance in this branch.

Telegraphy in the United States.—As telegraphy is practically a monopoly in the United States, the wholesome effects of competition do not exist, and therefore little progress may be expected here other than such as will enrich the companies. Improvements in the service and better accommodations to the public demands can be looked for only in so far as they will increase the revenue of the companies. The United States stands alone as the only one of the great nations which is not able to obtain control of the telegraph service of the country.

All the other great nations have long ago found that it was as necessary for the Government to control the telegraph as it was to control the postal service; the United States alone is in the rear. This is all the more strange, as this country is the birthplace of the telegraph, which was first developed here by Morse himself, with money appropriated by the Government from the public treasury.

Detailed description.—The following detailed descriptions of the principal exhibits is limited to a summary of the chief features of the exhibits. A full description of the details, though interesting and important, would be too lengthy to be included here. Most of the exhibits will probably be found fully described and illustrated in the technical journals and books on these special subjects. They have been divided here into the following classes: Single transmission, automatic, diplex, duplex, quadruplex, multiplex, multiple calls, cable transmission, and accessories. Unless otherwise stated, they were exhibited in the French section. The awards are not always mentioned, as in many cases they were given for a collective exhibit.

SINGLE TRANSMISSION SYSTEMS.

Historical.—The Western Electric Company (United States section) exhibited a sample of one of the first dispatches sent in 1844. It consists of a strip of paper an inch and a half wide, with the Morse characters indented in the paper. They also exhibited the lead type which was used in one of the original Morse automatic transmitters.

Hughes apparatus.—The Hughes apparatus, so largely used in France, has not been modified materially since 1878, when the me-

chanical controlling apparatus was being substituted for the electrical. In some of the larger stations power is being introduced, in the form of gas, steam, water, or other motors for winding up the weights. Several exhibits were shown for facilitating this winding up of the power weight. A modification introduced on some instruments is a double type wheel printing a duplicate message for various purposes, such as press dispatches, for instance.

Wunschendorff exhibited a cam attachment to the type wheel, for automatically moving a contact spring for making contact with a discharging battery.

Estienne system.—In the system devised by Estienne (French section, honorable mention), the usual horizontal dots and dashes are replaced by a short and long *vertical* line, respectively, printed on the tape by positive and negative currents. The advantages claimed are that the two signs have the same duration and are therefore independent of retardation, which therefore simplifies the automatic transmission; that the reading is simpler, the tape shorter, and the chances for error less. It is also more rapid, and therefore increases the capacity of a line. The key is a double one, sending positive or negative currents to line, in place of dots and dashes, respectively. The receiver is an ink writer, having a polarized armature which prints a short or a long mark according to the direction of the current. They are used in Germany and have been tried in France on underground lines and sea cables, as also from Paris to Berlin. But it was found that they were not altogether satisfactory, as they get out of order easily and require much regulation. The speed is only slightly greater than that of the Morse and considerably inferior to that of the Hughes.

Herodote modification.—Herodote modified the above system by making a small addition only to the usual Morse printer at present in use in France. He added simply another magnet and pen, but with a polarized armature, which printed vertically above the other, both of them printing vertical lines instead of horizontal. For a positive current only one of them printed, while for a negative current both printed simultaneously, producing therefore a short and a long vertical sign similar to those in the Estienne. Neither of these systems is, however, new, as an Englishman named Herring suggested a similar system of vertical signs with reversed currents as early as 1871.

Permanent charge system.—An ingenious system of Bouchard (French section, honorable mention) enables the number of cells used to be reduced to one-half, in a certain sense, by using half the number of cells at one station and half at the other. An equal number of cells is at each end of the line, with like poles to line. The sending key has an attachment to it which, when the key is depressed, reverses the poles of the sending battery, thus putting the two in series for the moment, and thereby sending a current to line. Though

ingenious, it can not well be adapted to lines which serve several different stations, which is often the case.

Steno-telegraphy.—An interesting departure from the usual systems of telegraphy was exhibited by G. A. Cassagnes (French section, silver medal). The principle of this system is that instead of

STENO-TELEGRAPHIC DISPATCH.

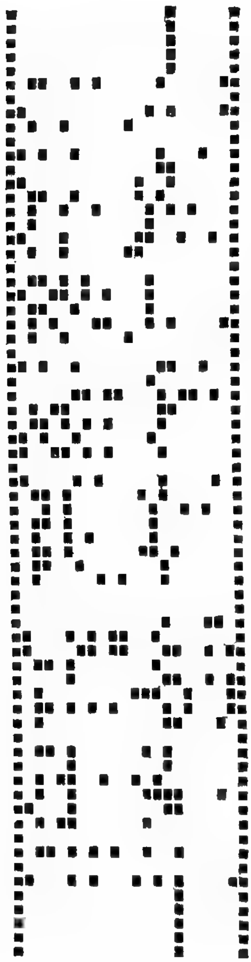


FIG. 17.—Perforated band, for transmitting.

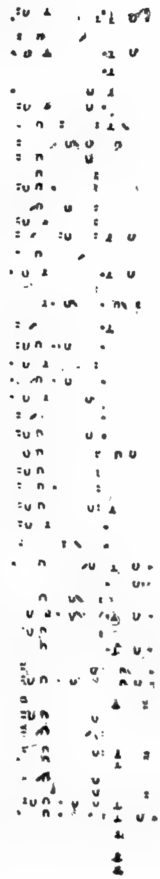


FIG. 18.—The dispatch as received.

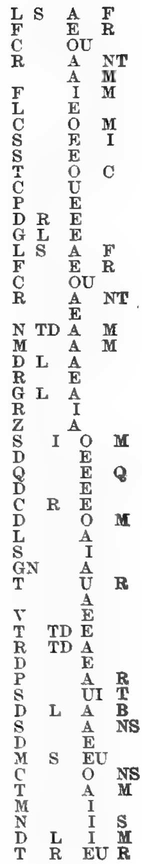


FIG. 19.—Translation of the characters into letters.

telegraphing *letters* as usual, he telegraphs characters representing the *sounds* composing the words. The advantages are, therefore, similar to the advantages of stenography over the ordinary writing. A message can thereby be sent as rapidly as it can be spoken. As

it takes much less time to transmit the characters representing the sounds, than it does the letters, the carrying capacity of the lines is greatly increased.

The system is briefly as follows: A band is perforated with holes representing the sounds; this is passed through the mechanical transmitter, which sends corresponding signals to line; on the receiver these signals are recorded as printed signs, which are then readily translated into the usual letters. Figures, 17, 18, and 19, will show the different stages of a message. A short paragraph from a daily paper was selected at random by the writer and was read to the operator about as fast as one would talk; the band was punched, transmitted, and retranslated, each about at the same rate. The paragraph which is given below contains 40 words and was read in about fifteen seconds. The first band, Fig. 17, is the one punched by the stenographer; the one next to it, Fig. 18, shows the corresponding characters as received, and the third one, Fig. 19, shows the message as translated from the second, by an operator on another machine. The paragraph is as follows:

LES AFFAIRES COURANTES.

Enfin le conseil s'est occupé de régler les affaires courantes et notamment de la régularisation de quelques décrets dont la signature avait été retardée par suite de l'absence de M. Constans, ministre de l'intérieur.

The first instrument, the perforater, is based on the principles of the Michela's stenographic machine, and consists of twenty keys arranged like those of a piano, which work twenty punches. These are worked with both hands by the stenographer, different combinations of the keys representing the different sounds. It is claimed that with this machine a skilled operator can stenograph 200 words per minute in any language.

The band thus punched is shown, half size, in Fig. 17. This is then passed through the mechanical transmitter which sends alternate positive and negative impulses to line corresponding to the perforations. These are sent over a single line by means of any convenient multiplex system, the one employed being the synchronizing system of La Cour, known as the phonic wheel, which is too well known to require description here. By means of it the twenty different impulses are received by as many corresponding relays at the receiving end, which operate the printer.

Every turn of the synchronizing wheel represents one line in the message illustrated above. The message thus received and shown in Fig. 18 is then translated into the usual written language. Fig. 19 is a literal translation of the characters in Fig. 18. It is claimed that 15 days suffice to learn to read the tape fluently and about 6 months to stenograph at the rate of 150 to 200 words per minute.

Besides the speed of transmission over the wire itself, the additional advantage claimed is that of the speed of preparing the message for transmission. It is in this feature that it excels the Wheatstone automatic system. It is claimed, for instance, that the first sentences of a speech begun in Paris at 2 p. m. could be composed in a printing office at Marseilles (about 540 miles distant) at 2.10 p. m., the stenographer always following the orator. Such a speech could be printed and distributed simultaneously in Paris and Marseilles. Experiments have been made on the French lines, in one of which, made in October, 1886, the following results were obtained: Up to 220 miles, 24,000 words per hour; up to 400 miles, 17,000 words; up to 569 miles, 12,000 words. The chief use would appear to be for press dispatches. As to actual speed of transmission over an average line it does not appear to exceed that of the Wheatstone automatic system, which is in use largely in England at the rate of 300 words per minute, and which has the additional advantage that the words are spelled as usual, thereby avoiding many possible errors.

Embossing and translating system.—In the Edison embossing and translating system the record of the transmitter is made in the form of a spiral groove on a circular revolving disk, by indentations in these disks. These may then be put directly into a transmitter for automatically repeating the message onto another line.

Train telegraphy.—The Edison-Smith system of telegraphing to and from moving trains consists essentially of a key, a phonetic receiver (telephone), and a high tension alternating current as produced by an induction coil. The train apparatus is connected between the metallic insulated roof of a car and the ground, through the wheels. The action depends on the static induction between the roof of the car and the fixed line wire on the poles alongside; and as the action is that of alternating condenser charges, it is independent of the regular Morse transmission on the same line. It is said to have been operated through an air space of 580 feet between the car and the line wire. Edison suggests this system for the intercommunication between ships at sea.

Telephonograph.—Lambrigot (French section, bronze medal) exhibited an apparatus called a telephonograph, which is a combination of a telephone and a phonograph, by means of which a message may be sent over a line as a telephonic message and recorded at the receiving end on a phonograph. This phonographic record on a strip of paper may then be retranslated into articulate speech by means of a similar phonographic apparatus and telephone. Its object is, therefore, the same as that of an automatic telegraph, namely, of increasing the capacity of a line by rapid transmission and subsequent retranslation at the receiving end.

The apparatus consists of a transmitter and a receiver; the former

is a telephone, the latter is a chemical phonograph of special construction. In appearance it resembles the ordinary original phongraph, but the tin foil is replaced by a piece of tinned paper, and the engraving needle is replaced by a fixed pen, which moves lightly over this paper and is filled with a decomposable liquid; this traces the usual spiral line over the paper. The telephonic line current passes through this pen to the paper and decomposes the liquid in exact proportion to the varying current strength, leaving an indelible record of the oxide of greater or less depth and therefore of proportionate resistances. This record is permanent, and may be removed from the apparatus. To retranslate it, it is placed on a similar phonograph in which the pen is replaced by a light metallic point. A current from a cell is passed through this point to the paper and through a telephone. On turning the phonograph cylinder the variations of the resistance due to the different thicknesses of the oxide on the record produce corresponding variations in the current strength, and thereby reproduce the same sounds in the telephone. Very good results are said to have been obtained, though the apparatus as exhibited has not yet passed the experimental state. It has not yet been used in practice.

Autographic.—The apparatus of Jordey in the French section and that of Edison in the United States section, for transmitting facsimiles of writing or drawings, are already well known and were exhibited in the exhibition of 1881.

Gray's Telautograph.—Among the most interesting exhibits of new departures in telegraphy were two small records of autographic telegraphy exhibited in the personal exhibit of Prof. Elisha Gray, in the United States section, and for which, together with his historical exhibit, he was awarded the high honor of a grand prize. Facsimiles of these two records are given below (Figs. 20 and 21), full size, and will explain themselves.

The apparatus, though promised for the exhibition, was, unfortunately, not sent, nor could the writer obtain a description of it, as the inventor was not ready to make it public. All that can be stated here is that the pencil of the transmitter is free to be moved in any direction within the rectangular space, and can even be lifted off the paper and started again at any desired place, thereby permitting line drawings to be sent; the receiving pen will make precisely the same movements. The two facsimiles below will show the almost absolute identity of the transmitted and the original messages. It is believed that two line wires were required, but possibly there was only one. Fig. 20 is the original pencil copy and Fig. 21 the transmitted ink copy.

AUTOMATIC TELEGRAPHY.

The automatic systems, in which the message is prepared in the form of a perforated band, which is then passed rapidly through the transmitter, are coming into use rapidly and represent probably the most important direction of the development of telegraphy. As the main object is to increase the carrying capacity of a line, it is to a certain extent a competitor of the multiplex systems and can in many respects be compared directly with such systems.

Historical.—The idea of the automatic transmission is not new, as was shown by an exhibit by the French telegraph department of

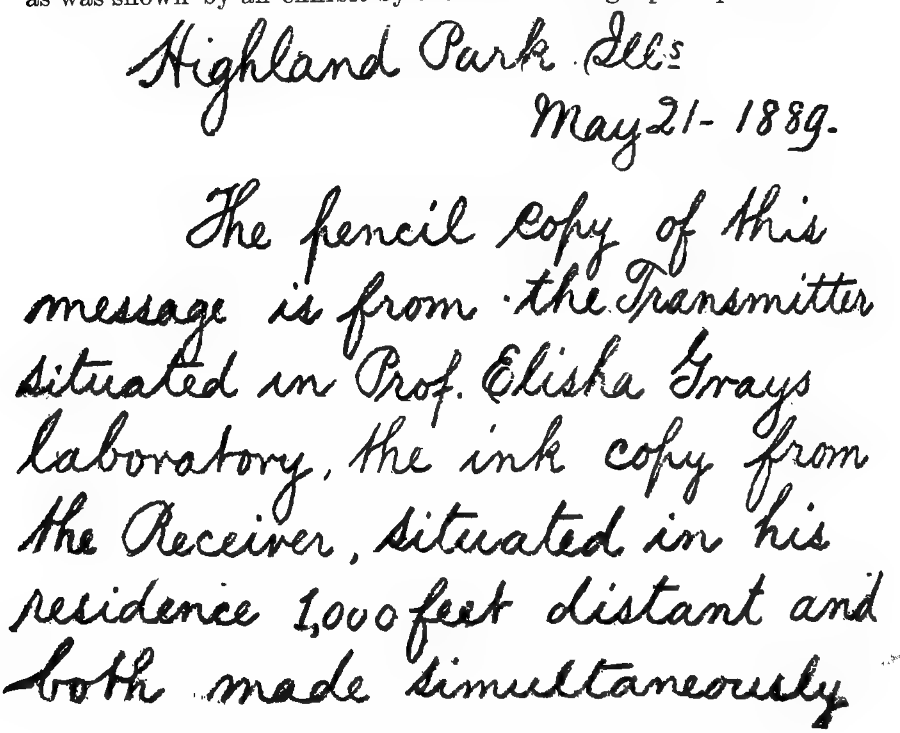


Fig. 20.—Gray's telautograph. The message as sent; pencil copy. For description see page 105.

an apparatus of Chauvassaigne, of 1865, in which the Morse characters were printed with a resinous substance on a metallic band, which was then passed under a contact brush. The receiver was an electrochemical one. One of the first Morse systems was also an automatic one, the message being set up in types representing dots and dashes, which were then passed under a make-and-break contact.

The most important of these automatic systems is unquestionably the Wheatstone, which is already in use largely in England and, to some extent, in France. With recent improvements it is enabled to transmit as many as 600 words per minute, used alone, and 400

words when duplexed. The former would replace 30 operators at the ordinary receivers, at 20 words per minute. The normal running rate in England is 300 words per minute. The apparatus was exhibited by Elliott Brothers, of London (British section, grand prize), and represents a very high degree of perfection in fine workmanship, in which it can be compared only with the workmanship in fine watches.

The general principle of the apparatus is briefly as follows: A tape is prepared by the punching apparatus shown in Fig. 22; the three

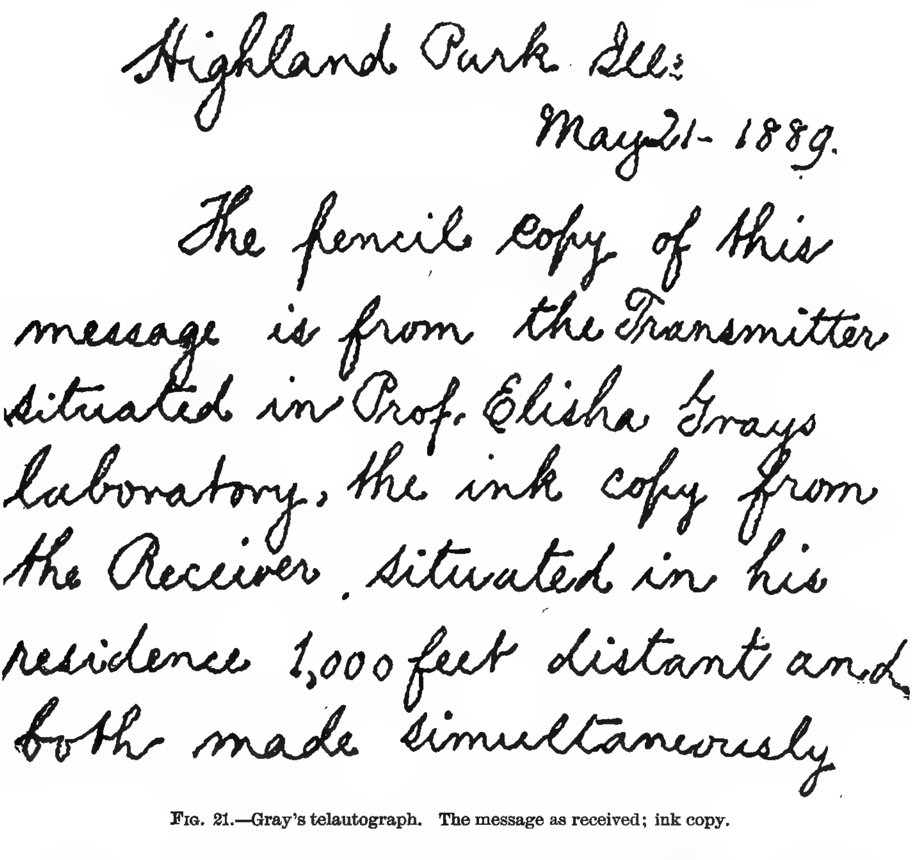

Highland Park Ill:
May 21- 1889.
The pencil copy of this message is from the Transmitter situated in Prof. Elisha Grays laboratory, the ink copy from the Receiver situated in his residence 1,000 feet distant and both made simultaneously

FIG. 21.—Gray's telautograph. The message as received; ink copy.

knobs represent dots, dashes, and spaces; the middle row of holes (which is regular) is for feeding the tape through the transmitter; the two outside rows represent the dots or dashes according as the two holes are vertically over one another, or as one is in advance of the other.

The tape, thus prepared, is fed into the automatic transmitter shown in Fig. 23, through which it is carried by a rapidly revolving wheel driven by a weight at the rate of 600 words per minute, or

about four times as fast as the message could be spoken. The tape thereby passes over two contact springs, which send a positive or negative current to line according as there are perforations on one side or the other; when the two follow one another almost instantly

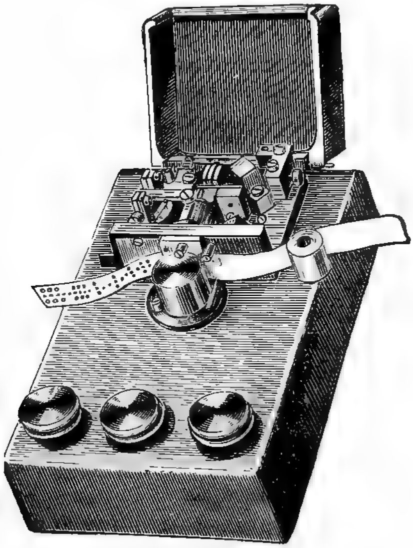


FIG. 22.—Wheatstone perforator for automatic telegraphy; by Elliott Brothers, England.

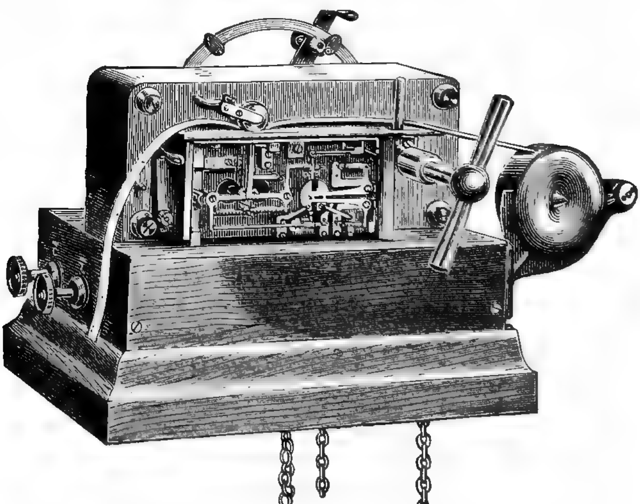


FIG. 23.—Wheatstone automatic transmitter; by Elliott Brothers.

a dot is produced on the receiver, and when they are not over each other a dash will be produced.

The great rapidity of the succession of the currents is rendered possible by the fact that the line is discharged every time by the

reversed current. Sparks at the contacts are avoided by small condensers of one-tenth microfarad placed in derivation between the transmitter and the line.

In the receiver shown in Fig. 24 a tape is, by similar mechanism, drawn through very rapidly, passing under a very light ink roller, which is operated by the receiving magnet. The retarding effect of the electromagnetic inertia of the receiving magnet is reduced by the addition of shunted condensers. For distances over 300 miles relays must be used. The exhibit included these relays, as well as special condensers and resistances for balancing the lines without interruption of the message when the line is working as duplex.

The apparatus, though simple in principle, is quite complicated in construction and can not be described here. For a description of

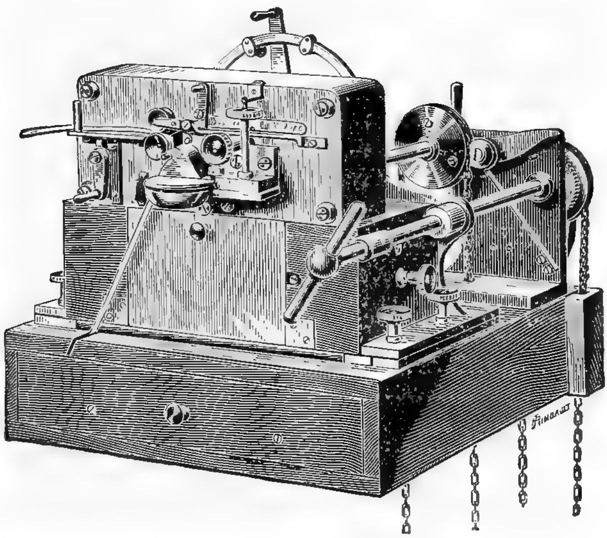


FIG. 24.—Wheatstone receiver; by Elliott Brothers.

the recent improvements see the paper of Mr. W. H. Preece, read before the British Association for the Advancement of Science, September 5, 1887.

Meyer Automatic Repeater.—In the Wheatstone system, if a message is to be retransmitted on another line it is necessary to translate it and perforate another tape, which is a cause of delay and expense and introduces errors. To avoid this Meyer has modified the system so that the receiver not only prints the characters, but at the same time punches its tape with holes, so that it can be passed directly through another automatic transmitter. The ink record is in this system in long and short vertical lines, as in the Herodote system, described above, and is accompanied by the corresponding perforations. It is stated that with this system one hundred dis-

patches per hour can be transmitted, which, as will be noticed, is very considerably slower than with the Wheatstone apparatus. It has not yet been tried in practice.

Estienne Automatic.—The Estienne system, described above, was also arranged so as to be used as an automatic apparatus with perforated tape. But both this and the Meyer have the disadvantage that the current is not necessarily reversed for every impulse, as in the Wheatstone, and that the speed therefore must be considerably less.

Hughes Automatic.—Modifications were devised by Nault and others by Parment for making the Hughes apparatus automatic. Though ingenious, they are too complicated to be described here. Those of Parment were to a large extent only in the form of drawings.

References.—The embossing system of Edison, and the stenotelegraphic system, both of which are described above, might be classed under this heading of automatic systems. For an automatic transmitter for cables see "Cable telegraphy," below.

DIPLEX SYSTEMS.

In the diplex systems two messages are sent simultaneously in the same direction. Sieur exhibited several methods. In the first a rapidly revolving toothed wheel at the transmitting end connects the line alternately with the positive and negative poles in very rapid succession. At the receiving end these currents pass through a polarized relay with two armatures, one of which will respond to a positive and one to a negative current. Each of the two receivers operated by this relay will therefore respond to the signals from the positive and the negative keys, respectively, at the transmitting end. In the second method a relay has a double armature, one of which responds to a weak current only and one to a strong current. The two keys at the transmitting end send currents of different intensities. In the third method one message is sent by the ordinary direct current and the other by an alternating current. The latter is produced by a tuning fork and an induction coil, and is again transformed in a similar induction coil at the receiver. The phonetic relay at the receiver has a double polarized armature, which in oscillating rapidly, due to the alternating current, will operate a sounder. The alternating current will not interfere with the ordinary direct current transmission.

DUPLEX SYSTEMS.

In the duplex systems two messages are sent simultaneously in opposite directions. In one of the Edison duplex systems, operator No. 1 sends impulses by reversals of the current, which operator No. 2 receives on a polarized relay. Operator No. 2 sends impulses

by varying the strength of a direct current, which operator No. 1 receives on an ingenious double balanced relay, which responds only to changes of the current strength in one of the magnets, but not to reversals of the current in both—that is, not to the reversed currents of the transmitter No. 1.

In another Edison system there is an induction coil having two secondary and one primary circuits. The receiver is in the primary circuit. The receiving current passes through both the secondaries in the same direction, and thereby operates the receiver; but the sending current passes through them in opposite directions, and therefore does not operate the receiver. To accomplish the latter, the sending current passes through the two secondaries in multiple arc, through the one to line and through the other to an artificial line.

In still another duplex system of Edison, called the phonoplex, one of the transmissions is by the ordinary Morse system, except that, in addition, a condenser shunts the receiver and the key, which therefore does not affect this transmission. The other transmission is by means of momentary high-tension currents and a telephone, the transmitters and receivers of which must all be between the two Morse stations. The Morse current is too gradual in its action to effect a sharp click in the telephone; while the high-tension current is too small in quantity to affect the Morse receiver. The high-tension current will get to ground whether the Morse key is open or closed, owing to the condenser shunting the key. The high-tension current is produced by a key which makes and breaks the local circuit of a self-induction coil in the line circuit, the extra current from which will pass to line in order to get to ground at both ends, and in doing so passes through the telephone receivers. The second transmission may be introduced between any two points on an existing line. It is used largely in railroad systems in the United States.

Duplex Hughes.—The duplexing of the Hughes apparatus by Terral is not new and has already been exhibited. The system used at present is that of differentially wound magnets.

Phonopore Telegraphy.—Langdon-Davies (British section) exhibited a system of telegraphy by means of an apparatus called a "phonopore." The object is to transmit independent messages over a line while it is being used for the ordinary Morse transmission, without interfering with the latter; also to diplex or duplex the phonopore transmission independently of the Morse transmission, thus enabling three messages to be sent simultaneously over the same wire. This latter was exhibited in operation.

In the phonopore transmission the sending key and the receiving sounder or printer are the same as usual; the special apparatus interposed between the key and the line is called the *phonopore*, and that between the sounder and the line is called the *transformer*. The

phonopore consists of an induction coil having one primary wire and two secondary wires. In the primary circuit is placed the sending key, the battery, and a vibrating reed, which therefore enables primary currents of a very rapidly intermittent character to be sent through the coil. One of the secondary coils has one end insulated and the other end to line; the other has one end insulated and the other end to ground. The connection to the line is such that this whole transmitter is to a certain extent in multiple arc with the ordinary Morse sender, but with the important difference that the phonopore branch is *not* connected to ground and therefore does not affect the Morse transmission. The phonopore, however, virtually grounds the rapidly alternating phonopore current by means of the induction or condenser action between the two insulated secondary coils, one of which is to line and the other to ground; this feature is the essential principle of this system, namely, that the phonopore branch is virtually grounded (through an insulator) so far as the phonopore apparatus is concerned, but is not grounded so far as the ordinary Morse transmission is concerned.

The transformer is the receiving apparatus, the object of which is to receive this phonopore current only, and not the simultaneous Morse current. This transformer is connected, like the phonopore sender, in multiple arc to the independent Morse receiver, and is virtually connected to ground through a double-wound induction coil, one end of each of whose coils is insulated just as in the phonopore. It consists of a delicate relay, which is actuated only by an alternating current of the same number of alternations as that from the sending end. This is accomplished by a vibrating diaphragm opposite to an electro-magnet, somewhat as in a large telephone, but tuned to the same number of vibrations, or musical note, as the reed at the transmitter. An alternating current of this frequency only will vibrate this diaphragm, and in doing so the diaphragm, in striking against an ingeniously devised contact, will open the circuit of a relay, which in turn operates the usual printer or sounder.

Duplexing or diplexing of the phonopore transmission itself, independently of the ordinary Morse messages, is accomplished by the usual harmonic system of having the reeds at the two stations of different numbers of vibrations and their respective diaphragms tuned to the same note. All the rest of the apparatus is the same. The advantages of such a system of increasing the sending capacity of existing lines are evident, and need not be enumerated here. In addition, the inventor claims to overcome the delicate balancing or synchronizing in the usual methods of duplexing and to accomplish other useful results by means of his phonopore. A moderately good description, well illustrated, may be found in The Electrician (London), April 5, 1889. The system has been introduced on several lines in England.

QUADRUPLEX SYSTEMS.

The Edison quadruplex system is similar to the first one of his duplex systems described above, in which one transmission is by reversals of current and the other by changing the intensities of a direct current. There are, furthermore, two different strengths of currents used, by means of which this duplex is doubled. The separation of these currents is accomplished by an ingenious arrangement of the two keys and relays at each station as parts of a Wheatstone bridge. It is used largely in the United States. There are said to be over three hundred sets of these in use by the Western Union Company, which, it is claimed, saved them $500,000 the first year, replacing $16,000,000 of extra lines.

MULTIPLEX SYSTEMS.

The principal multiplex system used in France is that of Baudot (French section, grand prize), which has undergone important improvements since the Expositions of 1878 and 1881, and is now in use largely in France as simple, double, and quadruple. Though very complicated in its construction it is, like the Wheatstone automatic, quite small and compact, and in this it differs greatly from the large Hughes apparatus, which it is replacing. Among the recent improvements are the substitution of a small and very ingenious centrifugal regulator in place of the vibrating reed used before; the Siemens relays have been replaced by an original one, by which their number is greatly reduced; the translator, which was previously mechanical, is now purely electric. For a more detailed description, which could not be attempted here, see the technical journals, especially La Lumiere Électrique.

Multiplex Hughes.—Munier exhibited a device for transforming the Hughes apparatus into a multiplex one; the one exhibited being a quadruplex. It is able to transmit 125 letters per minute, and as quadruplex it could therefore transmit about 6,000 words per hour. Experiments made with it between Paris and Dijon proved quite satisfactory.

Radiophonic multiplex.—Mercadier exhibited a multiplex system termed "radiophonic," which belongs to the same class as the well-known Gray's harmonic system, in which the undulating currents produced by a number of vibrating tuning-forks of different pitch are sent through a common line and separated again at the receiving end by receivers of the same pitch, respectively.

In the quadruplex apparatus exhibited by Mercadier, the transmitter is a piece of selenium called the radiophone, on which a ray of light falls; this ray is intercepted by a constantly revolving disk having four series of holes around its circumference, producing

four sets of interruptions of the light. This will change the resistance of the selenium accordingly, and thereby produce corresponding vibrations in a current passing through the selenium. These holes are screened by four little movable screens, which can be moved by hand or by a magnet and key. The disk is kept revolving at a constant speed by any convenient motor, its speed being adjusted by an acoustic method. When these screens are moved to imitate the Morse characters, impulses of the undulating current corresponding to that particular note will be sent to line and to the respective receivers.

The receivers are telephones called by the inventor "monotelephones," the diaphragms of which are tuned to the required notes, and rest on three points corresponding to the nodal points of vibrations. They are furnished with resonant boxes and ear tubes. It is stated that these monotelephones will distinguish between sounds differing by as little as half a tone, thus enabling twelve notes, and therefore twelve different messages, to be sent simultaneously. The selenium radiophone may be replaced by a thermic one, in which a microphone is actuated by the expansion and contraction due to an intermittent heat ray.

In another system of the same inventor the transmitters are tuning forks, each with a microphone and an induction coil, as usual.

All these are probably only experimental.

MULTIPLE STATIONS ON ONE LINE.

Limon.—The receiver of the call devised by Limon consists of a toothed wheel, having as many teeth as there are stations on the line; at each station one of these teeth is in connection with the call bell at that station. The wheels at the different stations are all turned together by a step-by-step motion, produced by a succession of positive impulses of current from the transmitting station and received by a polarized relay. When the tooth of the wheel corresponding to the desired station is reached, a negative current is sent to line by the sending operator, which operates a second polarized relay; this closes the local bell circuit of that particular station whose bell is connected to that tooth. This negative current at the same time releases the wheels of all the stations, allowing them to return to zero.

Claude system.—The object of the very complete system of calls devised by Claude (French section, silver medal) is to enable any one station of a series connected on the same line to call any other and then to put itself into communication with that one alone, to the exclusion of all the others, and finally to put the circuits back into their original condition again.

The apparatus at each station consists of a double polarized relay

and two dials. The double relay is in the line circuit, and consists of a suspended double bobbin, capable of turning in the field of a strong magnet, one of which bobbins responds to a negative and one to a positive current. The dials are turned by clockwork controlled by this relay. A certain number of positive impulses brings all the dials to the corresponding number ; this is followed by a negative impulse, and then by the number of the calling station, after which the two are in communication, all the others being excluded by the fact that their receivers are cut out of the line circuit by their dials. All the dials are brought back by one of the operators by sending a sufficient number of impulses to bring his dial back to zero.

It is used chiefly for railroad and other similar service, in which a number of stations are on one line. It has been in very satisfactory use for a year on the Paris, Lyons and Mediterranean Railroad between Paris and Lyons, a distance of about 320 miles, with eleven stations, on No. 9, B. & S. gauge, iron wire. It is also recommended for similar telephone circuits.

SUBMARINE-CABLE TELEGRAPHY.

Hughes.—The Hughes apparatus was adapted to submarine cables between France and Algeria in 1882 by Mandroux. Though otherwise quite satisfactory in every respect, the speed was only 40 to 45 messages per hour, and it was therefore not kept in service.

Automatic transmission with siphon recorder.—Belz and Brahie exhibited a modification of the Wheatstone automatic transmitter, to adapt it to the siphon recorder. The currents from the transmitter are sent to the cable through a Froment relay. It is said to increase the capacity of the cable from 1,500 words per hour with the siphon recorder alone to 1,800 with the automatic transmitter.

System of working multiple cables.—As parallel conductors in a cable can not be worked independently for greater distances than 250 miles, the Commercial Company (of New York) operate their conductors in pairs as metallic circuits, and using each pair again as part of another circuit, with either another pair or with the earth as return. The chief claim is the perfect way in which this eliminates the inductive disturbances between neighboring wires. This company is the only one having a transatlantic cable ending in New York City, though the line includes a landing in Nova Scotia.

Vibrator for siphon recorder.—The Commercial Cable Company exhibited the Cuttriss vibrator, which is an attachment to the siphon recorder for cables, to replace the usual electrification by high-tension charges, the object of which is to vibrate the ink-recording siphon in order to eliminate the friction on the paper. The usual method has many objections, as it is affected by the moisture or dryness of the air and the paper.

In the Cuttriss magnetic vibrator there is a very small piece of No. 30 iron wire, about one-sixteenth of an inch long, secured near to the end of the siphon. The paper passes over a small iron table, which is the only addition which must be made to the usual instrument. This iron table is magnetized by an intermittent current, causing the end of the siphon to vibrate up and down rapidly, producing a series of dots. The intermittent current is produced by a simple make-and-break magnet, which has a sensitive mercury regulator to adjust the number of impulses to the natural number of vibrations of the siphon; otherwise the siphon would not vibrate regularly.

This system is used on all the instruments of this company and is highly indorsed by them. For a short description and an illustration see Electrical World, June 26, 1886.

Elliott.—Another and simpler vibrator similar to this was exhibited by Elliott Brothers. The siphon was attached by means of a string directly to the armature of the vibrating magnet in the rear of the instrument.

Telephone receiver for cables.—In the cable receiver of Ader the cable is connected to a vibrator which vibrates between two contacts. One of them connects it through a telephone to the negative pole of a grounded battery, the other connects it through another telephone to the positive pole of another grounded battery. A positive current in the cable will increase the sound in the first telephone and a negative that in the other.

Receiver.—For a cable receiver Edison suggests to use his motograph receiver, because of its sensitiveness.

Siphon recorder.—Chamroy exhibited an attachment to the siphon recorder by means of which the writing is done by a succession of sparks from an induction coil, the paper being prepared chemically so as to be discolored by the spark.

Cable relay.—The Eastern Telegraph Company (British section, gold medal) exhibited a relay devised by Brown & Allan to replace the siphon recorder. It consists, essentially, of a small coil suspended by a fine platinum wire, free to oscillate. It has a hollow core, and is placed in the magnetic field between two magnets. A small rod of soft iron, capable of turning with considerable friction around a vertical pivot, is moved by this electro-magnet. When the cable current passes through this electro-magnet it turns it to the right or left, which moves this rod up to a contact, where it remains, while the coil continues to the end of its oscillation. This contact closes a local circuit working a Morse receiver. It is used largely by this company for their submarine cables.

ACCESSORIES.

Keys.—The Arnauné key has two sets of contacts at each end of the rocking lever, the connections of which are such that the depres-

sion and releasing of the key will connect the positive or negative pole, respectively, to line and at the same time connect the other pole to earth, thus reversing the current for each impulse.

In the discharge key of Schaeffer, one end of the key lever is long, so as to increase the amount of motion, and has a spring attached to it, which at every motion up or down of the key touches, in passing, a contact connecting the line to ground, thereby discharging it before and after every impulse of current.

Farjou (French section, bronze medal) exhibited a number of keys for various purposes, which have given very satisfactory results. The first is for automatically connecting the line to ground for a moment only every time the key is released or raised. This is accomplished by a small movable ball which rests on a spring, which keeps an earth contact open. Every depression of the key strikes this ball, causing it to roll up an inclined plane, thereby relieving the spring of its weight and closing the earth contact of that end of the line. The ball, in returning, a moment later, opens the earth contact and the line is again ready for the next impulse.

In the double discharge key the line is not only put to earth as described, but a discharging battery is also put to line for an instant between the position of transmission and that of repose. This is accomplished by a sort of fork, one of the two prongs of which is touched by each motion of the key (the lower one being insulated), and by an ingenious snap spring the contact made thereby is broken immediately afterward. This fork is one pole of the discharging battery, the key lever being the line terminal, as usual.

In the compensating double discharge key the impulse of the current is divided into two parts immediately following one another, the first being that of the whole battery and the second that of a smaller battery. This is accomplished by a second snap-fork contact similar to the one just described, but closing the momentary contact of the whole battery during the downward motion of the lever, while the other acts during the upward motion.

Relays.—Sambourg exhibited a polarized relay requiring no regulation. Instead of polarizing the armature four electro-magnets are used, two of whose cores are connected magnetically to a permanent magnet, which gives to these cores a polarity opposite to that given to them by the line current which flows through all four. The attraction of these two is opposed to that of the other, and the one common armature will therefore move toward one or the other according to the direction of the current.

In the relay of Dutertre the core of the relay is polarized by an external fixed magnet, and is capable of turning under the influence of the current in the coil. In that of Mandroux the polarized armature is between four magnets, which are wound so that those facing each other are always of relatively opposite polarity, and those adjacent are of like polarity.

In the Baudot relay the coil is at right angles to a permanent magnet which supports the axis of the armature. The action of the magnet is normal to the axis of the armature, and the action of the electro-magnet is normal to the armature.

Motograph relay.—The Edison motograph relay is based on the fact that the friction of a sliding contact on a revolving cylinder of some porous material wet with potash is greatly diminished while the current passes. This cylinder, driven by clockwork, pulls a sliding brush by friction against the action of a spring. When the current passes, the friction diminishes, the spring predominates and closes a local circuit. It has the advantage that it is free from remanent magnetism and extra currents.

In his carbon relay the pressure produced by the magnet on a carbon button changes its resistance and thereby actuates a local circuit.

Reference.—For cable relay, see Cable telegraphy, above.

Receivers.—Among the receivers exhibited was a Morse receiver of Oudin, very light and compact, containing in it all accessories, including ten moist cells; another of Dini, of strong and rigid form and economical construction. The Morse receivers of the French administration are the same as those of 1878.

Sounder.—The Decamp sounder consists of a telephone in which the diaphragm in vibrating makes and breaks the current of its own magnet, like an electric bell, thereby producing a musical note to replace the click of the usual sounder.

Discharging device.—Godfrey (French section, silver medal) exhibited an ingenious and very simple system of discharging lines, which is said by good authority to be the best of all similar systems. It is for use chiefly for underground, submarine, or long aërial lines having considerable capacity. It consists simply of a coil having very great self-induction, which is connected from line to earth at each end, therefore in derivation to the battery and key, or receiver and key, of the ordinary Morse systems, according as it is the sending or the receiving apparatus. It has increased considerably the efficiency of the lines on which it is used and has replaced a number of relays which were formerly considered indispensable.

Artificial lines.—Clark, Muirhead & Co. exhibited their well-known artificial lines which are used in duplexing the submarine cables. They consist of strips of tin foil wound so as to act both as condensers and as resistances combined, similar to a line.

Automatic ground alarm.—The object of a device of Caréme & Houjeau is to sound an alarm in case the line is grounded accidentally, and is of use specially when a number of lines are operated by the same battery. It consists of a coil wound around a bar of zinc. It is placed between the battery and the key. If the circuit is accidentally grounded beyond the key, this coil will heat sufficiently to cause the zinc rod to expand and close a local bell circuit.

Dynamos for telegraphy.—Picard exhibited a system for replacing the batteries by a dynamo. The dynamo circuit is closed through a resistance of German silver wire, the middle of which is connected to ground. This resistance is then treated just as though it were a series of batteries, the currents for telegraphing being led off from different parts of it in accordance with the number of volts required, and from the right or left of the ground according as they are to be positive or negative. To avoid accidents due to grounds or short circuits, each of these multiple arc branches leading off from this resistance has a separate resistance in its circuit which is proportioned at the rate of 4 ohms per volt of the potential, so as to limit the greatest possible current to one-fourth of an ampère. The system exhibited was one for 100 volts and 10 ampères. The system is in use at the central office in Paris and is proving itself to be very satisfactory. The inventor estimates the economy as follows for a 6 horse-power machine: At 0.1 franc (2 cents) per horse-power hour, it will cost 14.40 francs per 24 hours, or 5,256 francs (about $1,000) per year, for a station like the central station of Paris. The equivalent, 10,000 cells, would cost 30,000 francs per year.

Wires.—For the requirements and tests of the galvanized iron line wire delivered to the French Telegraph Department. (See under "Wires, cables, and conduits.") Copper wires have been used by this department for several years. For telegraphic lines, copper wires of 2 to 2½ millimeters have replaced those of iron of 4 and 5 millimeters; for telephone city circuits eleven-tenths millimeter is used; for long distances it varies, that from Paris to Marseilles, for instance, being 4½ millimeters. Copper wires are required to have a resistance of less than 21.4 ohms per kilometer at 0 C. for a diameter of 1 millimeter. It must support a tensile strain of 40 to 42 kilograms per square millimeter, with an elongation of not more than 2 per cent. A wire of 2½ millimeters diameter must stand seven bendings in a vise.

For a description of the underground cables for the city of Paris, see "Wires, cables, and conduits."

TELEPHONY.

GENERAL.

As there is no fundamental patent for telephony in France the natural result is that the telephone, as an apparatus, is being developed much more rapidly there than in this country. There is much wholesome competition both among inventors and among makers; the telephones are consequently better, cheaper, and as they can be purchased by anyone they are coming into use very largely in private installations. The latter was particularly noticeable to an American. Almost every exhibitor of electric bells and annunciators

had his system of house telephones; some at the exceedingly low price of a few dollars for two complete sets. They appeared to be as common as exhibits of electric bells and annunciators, and are being introduced about like these. Some makers are introducing them by thousands. Such systems are almost always two simple magneto telephones (without a battery) both as receivers and transmitters; or in some there is a simple microphone transmitter connected directly to line without an induction coil. In the best systems for longer distances the microphone is always used with the induction coil.

Progress.—The telephone as a receiver may be said to be one of the few inventions which have remained in practically the same form in which they were born. The telephone receivers used at present in the United States, England, and France are practically the same as those first introduced in the United States; they have been modified only very slightly in their proportions. Many radical changes and improvements have been suggested and are used, but by far the largest number in the large exchanges are still of the original types. As a transmitter it has given place to the microphone, except for very short distances.

Most of the progress in the instruments was made prior to the exhibition of 1881; that made since has been mostly in the systems, in the details, in the proportion of the parts, and in their improvement for special purposes, such as for long distances, etc. As a commercial apparatus it may be said to have been developed almost entirely since the last international exhibition in 1878.

Telephone systems in France.—The systems and apparatus are much better than in this country, the transmission being very clear and distinct. The transmission of music from places of entertainment is particularly fine and clear, especially in the installation at the exhibition. The *service* in the city of Paris, on the other hand, is exceedingly poor and far inferior to ours, especially since the Government has taken possession of the exchanges. The answer to the calls are so long coming that one does not generally wait at the telephone itself for this answer. For important messages within the city limits a messenger in a carriage is still frequently preferred to the telephone. One of the causes of delay is that the city is divided into numerous subcentral stations connected by trunk lines, and it is necessary in many, if not in most calls, to retransmit the call to another station. The Government has recently taken possession of the telephone service; the immediate result was a great increase in complaints of poor service; but it is too early at present to draw any conclusions as to the inadvisability of the Government owning and operating the telephone service.

Telephony in the United States.—Telephony being, even more than telegraphy, a monopoly in the United States, the wholesome effects of competition do not exist, and little progress can therefore be

expected at present other than such as will enrich the companies. The service, as distinguished from the apparatus and systems, is probably better than in other countries, but even at its best it often leaves much to be desired. The apparatus and systems are, however, inferior to those of France. The transmission is not nearly as clear and distinct, and the circuits are much more subject to interferences and to interruptions. One explanation, and not an unreasonable one, why improved apparatus is not being introduced more rapidly is that there is such a very large number of apparatus in use already that to change it all would be an unwarranted outlay of enormous proportions; besides, a change in apparatus often involves a change in the system. One result of the monopoly, which is much to be regretted, is that private installations and house telegraphy are practically prohibited here. In France the private telephone is in common use, like the speaking tube; here it scarcely exists.

Exhibits by countries.—Exhibits in this class were confined entirely to the French and United States sections. In the former they were very common, the finest and largest being the excellent exhibit of the Société Générale des Téléphones (grand prize), who have until quite recently had complete control of almost all the telephone service of France until it passed into the hands of the Government in September, 1889. Among the other French exhibitors the one most prominent, and especially noted for excellent workmanship, was Branville & Co. (gold medal). In the United States section were the large and very creditable exhibts of the Bell Telephone Company and the Western Electric Company, which attracted much attention among European specialists; the others were historical exhibits of the researches of Edison and of Gray.

Detailed description.—The accompanying detailed description has been limited to a very brief one, as this branch, not being public property here, is of little interest to the electricians in general.

Historical.—The historical exhibits of telephones were confined almost entirely to the United States section. The Western Electric Company included among its exhibits quite an extensive historical collection of American telephones. It was confined almost entirely to the different commercial forms and not to experimental models. Among them was one of the first commercial telephones, consisting of a U-shaped magnet, having two parallel soft iron pole pieces, around which were wound the bobbins. The diaphragm was not attached to either; that is, it was not polarized, strictly speaking, but was under the influence of both poles combined. In the Edison exhibit there was also a historical collection of experimental telephones, showing the researches of Edison in this field. Illustrations of these, but not accompanied by a technical description, will be found in the Electrical World, October 5, 1889, p. 234. In the personal exhibit of Elisha Gray were shown the original water tele-

phone described in his caveat of July 14, 1876; also his tone receiver of 1874 and the one of 1876, made for the Centennial Exhibition; also his strap and his violin receiver, both of 1874.

In the exhibit of the Société Générale des Téléphones were a large number of historical apparatus of the very extended researches of Ader. Among these was an old Reiss form of receiver, consisting of a simple electro-magnet having a block of wood secured to the one end of the core and a handle to the other end. The longitudinal vibrations of this core, due to the rapid changes of magnetization, are communicated to the block of wood. It is said to talk very well, even without an induction coil in connection with the microphone transmitter.

RECEIVERS.

Ader.—The receiver of Ader, exhibited by the Société Générale des Téléphones, is shown in Fig. 25. The magnet is in the form of a circle, which answers at the same time as the handle of the instrument. On its two poles are secured the soft iron pole pieces, around each of which are placed the bobbins, B B. The case, O, inclosing these, forms a resonant air chamber, closed at the top by the soft iron diaphragm, M M, which is secured at its periphery by the trumpet-shaped cap, E. In the latter, and quite close to the diaphragm, but not touching it, is secured a soft iron ring, X X, which is called the exciting armature. The caps are of hard rubber, and all the metallic parts are nickel plated. Two of these are usually used in each installation, one for each ear.

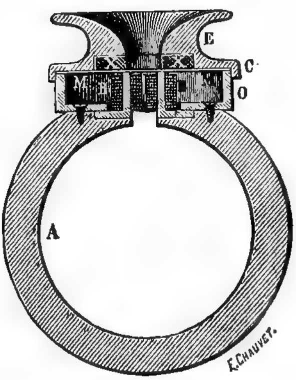


FIG. 25.—Ader's telephonic receiver.

This is the receiver which is used almost exclusively in all the telephone exchanges in France; besides being very simple in construction, it is an excellent receiver as such. It appears to be especially good for the telephonic reception of music. With the exception of the exciting armature, X X, it is identical (except in proportions) with one of the first commercial forms used in the United States, and exhibited as a historical model by the Bell Telephone Company.

Double diaphragms.—The magnet in the Ochorowicz receiver is in the form of a long hollow cylinder, split longitudinally and having its two poles at these edges, to which the two parallel soft iron pole pieces, surrounded by their coils, are attached nearly radial to the cylinder. There are two parallel diaphragms, one, as usual, above the two pole pieces, and the other next to the magnet, and below the

coils, fastened to the magnet at one point only, and having two holes larger than the coils which pass through it, so as to allow it to vibrate. These two diaphragms are connected together by a ring at their outside edge forming a sort of flat box, which augments the sound by virtue of its resonance. In the form exhibited by Hutinet there are two separate diaphragms acted upon by the same magnets to increase the resonance. By means of a short flexible tube and mouthpiece attached to the one in the rear, the same telephone may be used as transmitter and receiver, for short distances. In the Aubry form with two diaphragms, the magnet is very small and light, in the form of a closed horizontal ring having two projections in the inside containing the vertical pole pieces and coils. This ring magnet is attached to the center of one diaphragm of German silver. This will therefore vibrate together with the other diaphragm (which is, as usual, magnetic and opposite the poles) and will reinforce the sound. It is said to be particularly sensitive.

Concentric poles.—In one of the d'Arsonval forms the two poles are concentric, one being a cylindrical core and the other of annular form encircling it. In another the magnet is somewhat like the form of the letter S, the two poles terminating respectively in a cylindrical core and an annular piece encircling it. In one of the Testor forms the poles are concentric, and the diaphragm has a hole in the center below which is a concave reflector to reflect the sound.

Polarized diaphragms.—In the Colson form the diaphragm is between two magnets, one of which polarizes it and the other acts as usual on the diaphragm. In the Pollard form there are a number of small horseshoe magnets with like poles at the center connected to the soft iron pole pieces; the other poles are connected to an iron ring to which the diaphragm is secured by its circumference. In the Sieur form the magnetic disposition is similar, but it consists simply of a bar magnet having one pole at its center and two like ones at the ends, which latter touch the outside edge of the diaphragm.

Almost all of the last three groups of telephones were made and exhibited by de Branville & Co. (French station, gold medal).

TRANSMITTERS.

Most of the above-described receivers are used also as transmitters for short distances on private lines.

Microphone transmitters.—The transmitter of Ader exhibited by the Société Générale des Téléphones is shown in Figs. 26 and 27. The first shows a complete telephonic installation, of which the microphone is the horizontal slab. The second is a view from below up, showing the carbons of the microphone, and the induction coil. The microphone consists of a thin horizontal plate of deal 2 milli-

meters thick resting on a frame of soft rubber to deaden the mechanical vibrations communicated to it from the apparatus. On the lower side of this wooden diaphragm are secured three crosspieces of carbon, *d*, *b*, and *c*. The twelve cylindrical carbons, E E, rest loosely in holes in these cross pieces, forming twenty-four contacts, which may be connected, as shown, four in series and six in multiple, or, by connecting one lead to the center pieces and the other to the two end pieces, they may be coupled two in series and twelve in multiple. This is the transmitter used almost exclusively in the telephone service in France. The same form is used also for the transmission of operatic and concert music in Paris.

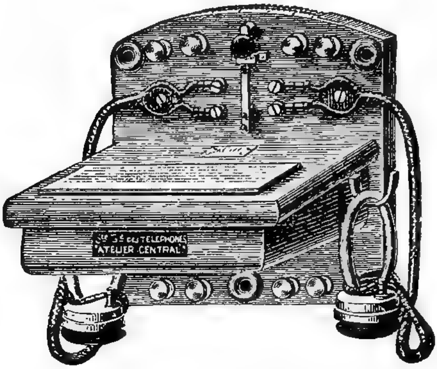


FIG. 26.—Ader's microphone transmitter. Front view.

In the microphone of d'Arsonval & Bert the rods of carbon have a ring of thin soft iron around their center. Opposite to these is a magnet which exerts a certain elastic force on these loose carbons and which is claimed to prevent some of the objectionable noises which so often accompany the transmission. In the form devised by Abdank-Abakanowicz there are four little carbon disks which rest, in vertical planes, loosely on their periphery on a slightly inclined flat piece of carbon on one side and against a thin piece of carbon on the other side. The latter piece of carbon is on the back of the wooden diaphragm. Their weight keeps them in contact with both. The vibrations of the diaphragm tend to roll these up the inclined plane on the opposite side, which keeps turning the disks so as to keep changing the points of contact. These four disks are connected two in series and two in multiple arc. In the Lagache form there are short carbon bars hinged at one end by a carbon rod which passes loosely through a hole in the bars, their other end resting loosely on a carbon plate. In the Mandroux & Peequet form there are two separate microphones on the diaphragm, each of which has

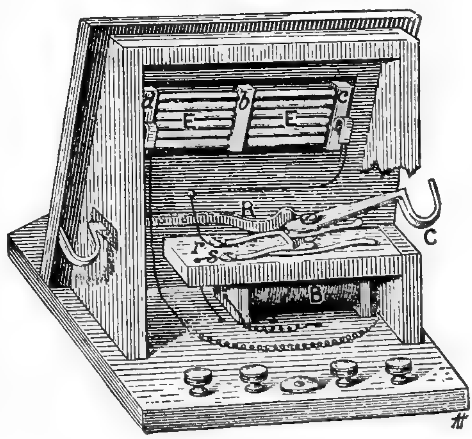


FIG. 27.—Ader's transmitter. View from below.

its own independent battery. The induction coil has one common secondary and two primaries, one for each microphone. It is said to be used especially for long-distance telephony. In the Van Rysselberghe form for long distances, the eight microphone rods are all connected in multiple arc to obtain as low an internal resistance as possible. In the Breguet form there are six radial rods, all having one end supported by one common block in the center of the diaphragm, the other ends being supported around the periphery.

Powdered carbon.—The American Bell Telephone Company exhibited a transmitter made of a layer of powdered carbon between two thin disks of platinum. It is always in a vertical position. When the powder has settled or has become packed it may be loosened by shaking the apparatus. It is used in the United States on their long-distance lines. The Hipp form (Swiss section) is very much like this, only that the box is not quite filled, so that by turning or inclining it one can loosen the material. This box is placed inside of another box having a mouth piece, the axis of the disks being perpendicular to that of the mouthpiece; over the inside end of the mouthpiece there is a stretched membrane of parchment; the sound waves act on both sides of this microphone, thereby increasing the actions. Up to 25 and 30 miles this can be used without an induction coil and gives excellent results. It is used in Switzerland and Italy. In the Berthon form there are two parallel disks of carbon separated slightly from each other; a portion of the space, bounded by a cylinder of hard rubber, is filled with grains of retort carbons; on inclining the apparatus these come in contact with the upper plate and form a microphone. In the microphone of Waden (Finland section, bronze medal) there are two parallel diaphragms of carbon close together; one is connected to the diaphragm proper and vibrates with it; the other is fixed. One of them has a number of grooves on one side, in which are placed about fifty little carbon cylinders 2 millimeters in diameter and 3 millimeters long. These are held in place by the grooves and form the microphone contact between the two, when they are in an inclined position.

Ader long-distance telephone.—In the long-distance telephone of Ader there are two carbons secured together and to the diaphragm, but separated from one another by a short space, and insulated from each other. In the space between them rests a wedge-shaped piece of copper, platinum plated, making contact with both of these carbons. One carbon being secured to the vertical diaphragm and the other being some distance back of it, the line through the contacts is perpendicular to the diaphragm. When the diaphragm vibrates it increases the pressure on one of these contacts and diminishes that on the other, and vice versa. The current enters by this copper contact and divides into two branches; these pass in opposite directions through the two primary coils of a three-wire induction coil, the

single secondary of which goes to line. The effects of the currents from the two microphones will consequently be in the same sense and the induction in the secondary will be proportional to their sum.

ACCESSORIES.

Switch boards.—The subject of switch boards is one of the few branches which are of interest only to a few specialists, and not to the electrician in general. A description of such apparatus is therefore of no interest unless given very completely with all details, which would not be possible in this general report. Furthermore, specialists are better able to study the subject from published detailed and illustrated descriptions than they would be from a general and brief report like the present. It was, therefore, thought useless to give here more than a mere mention of the chief exhibits in this branch.

The largest and most complete switch-board exhibit was that of the Société Générale des Téléphones. The exhibit included several sections, or "units," of a multiple switch board for 3,000 subscribers, and is the type to be used in the Paris service. It is very complete in all details, but is necessarily very complicated. Each of the 15 sections forming the complete board for 3,000 subscribers embraces 200 subscribers, and requires two attendants, one for each 100 subscribers. Each attendant can connect any one of his 100 subscribers to any of the 3,000, directly as the terminals of all the latter are within his reach in his or in one of the neighboring sections. Trunk lines connecting the several central stations are connected to the switch board the same as subscribers. Each central station is connected to each of the others, by a number of trunk lines; only in very few cases would two trunk lines be necessary for one connection. All the circuits are double wire, or metallic circuits, but the switch board is said to occupy no more room than if the circuits were single wire or grounded, as is usual in the United States. All the calls are battery calls; no magnetic ones are used. Lalande batteries are used altogether, three cells for a microphone, and twelve to fifteen for a call. Among the details are means permitting the attendant to connect himself in multiple arc with a circuit in use in order to hear whether the conversation is going on, and another connection in series permitting him to hear and also to speak; also another enabling him to find out whether a trunk line is in use or not without interrupting the conversation, should it be in use.

The Western Electric Company (United States section) also exhibit a section of a multiple switch board for double wire circuits, such as is used here for the long-distance lines. It is, in general, similar to the one mentioned above, but differs in its details.

Mandroux (French section) exhibited a simple board for fifty subscribers, for single line circuits.

Sieur (French section) exhibited a number of switch boards for single or double circuits. One of the characteristic features is that all connections are made by means of hooks at the ends of flexible cords. There are one, two, or four of these at the end of each cord, depending on the number of connections to be made simultaneously.

Calls.—In the call of Sieur a brass wheel, with iron teeth on its periphery, is made to turn so that the teeth pass by a polarized electro-magnet. The alternating current generated is sufficient to produce a sound in the telephone audible several yards off. Zigang's electric trumpet consists of a diaphragm at the bottom of a trumpet-shaped tube, which is vibrated by the action of the electro-magnet, like in a telephone, the current being made and broken by the diaphragm itself, as in a bell. In the call of Sieur & Van Rysselberghe, the telephone is used as a sort of relay to operate a local bell circuit. A contact made of a sort of pendulum resting against the diaphragm, is in shunt circuit to the bell; when the membrane vibrates, this contact becomes a poor one and the greater part of the current goes through the bell. The vibrating current is produced at the sending end by a push button and an ordinary vibrating interruptor.

SYSTEMS OF TRANSMISSIONS.

Several telephones on the same circuit.—In the system of Berthon, of the Société Générale de Téléphones, two subscribers on the same metallic (double wire) circuit are enabled to call each other without calling up the central office. This is accomplished by a second call button at each of these two telephones, which connects one of the lines with the ground, forming a circuit independent of the other metallic circuit. A bell at the other subscriber responds to this grounded circuit, but the annunciator at the central station, being on the metallic circuit, does not respond. The system of Ader permits the central station to call any one of the four subscribers on the same metallic circuit. The line is grounded at the middle of the loop, leaving two subscribers on one side and two on the other. At the central stations there are four calls from a grounded battery; one sends a positive current and another a negative current to one-half of this loop; the other two send a positive and a negative current to the other half of the loop; the calls at their four subscribers respond, respectively, by means of polarized relays, to one and only one of these currents. In the Sieur system for three subscribers, one annunciator responds to a positive grounded current, another to a negative grounded current, while the third responds to a current on the metallic loop. In the Sieur system for four subscribers, two of the annunciators respond only to a weak current, one to a positive and one to a negative current; the other two respond to a strong current, one to a positive and one to a negative current.

Telegraphing and telephoning on the same circuit.—In the system of Van Rysselberghe the telegraph currents are made to vary gradually instead of abruptly, in which case they will not be heard in the telephone; furthermore, their succession is insufficiently rapid to produce a note. This is accomplished by electromagnets in circuit between the receivers and the line, and by condensers having one of their poles to line and one to ground; furthermore, by a condenser of one-half microfarad, called a separator, between the telephone and the telegraph line; two of these are used when the circuit is metallic. These condensers form a screen to the telegraphic currents, but allow those from the telephone to pass. Up to 200 kilometers (125 miles) iron wire can be used, but for greater distances bronze wire is essential; the size varies from 2 millimeters for 250 kilometers, to 5 millimeters for 2,000 kilometers. This system is used in France on interurban telephone lines between Paris and Rowen, Havre, Lille, Rheims, and others; also Paris to Brussels, and on 7,466 kilometers (over 4,600 miles) of lines in Belgium. It is also used in many countries in Europe and America, including the United States. In the Maiche system for metallic circuits only, there is an induction coil with three circuits at each station. The microphone current passes through the one primary; the two secondary coils are connected in series and close the end of the loop of the metallic circuits; this completes the telephone connections. One end of the telegraph circuit is grounded and the other passes to the junction of the two secondaries, and thence through both in multiple arc to the two lines, which latter are therefore in multiple arc as one line; the currents in these two branches of the telegraph line then pass through the two secondaries in opposite directions, and will therefore have no influence on the primary at the receiving station, which contains the telephone receiver. Trials were made in 1885 on several of the long-distance telephone lines in France.

Domestic telephone systems.—Private telephone systems, for private houses, factories, etc., are developed to a very much greater extent in France than in the United States, due to the fact that there is no fundamental patent there to interfere or to make such use practically prohibitory by high royalties. Exhibits of such telephones were very numerous in the French section. They are as a rule simple magneto telephones, without battery or microphone. Some are with microphone but without induction coil. There is very little of special interest regarding them, to be described here.

Operatic telephone transmissions.—In the exhibition building of the Société Générale des Téléphones, there were a large number of telephones connected with the opera house, and several other places of amusement where the entertainment was entirely of a musical nature, as distinguished from that in the theaters. The system was a double one, there being two microphones on the stage by the front

footlights, one to the right and one to the left; these were connected by independent circuits, each to a series of telephones at the receiving station; each listener had two telephones, one on each circuit. There were about twenty to thirty sets of these on one line. The circuits were all underground, and metallic, some being a number of miles long. The transmission was remarkably perfect and clear, and there was an entire absence of the objectionable by-sounds. The transmission was equally good for instrumental as well as vocal music; a person skilled in orchestral music could not only distinguish readily between the string and the wind instruments, but could even distinguish between those of the same class, as for instance between a flute and a clarionette.

MISCELLANEOUS.

To an American, one of the most prominent features of the whole telephone exhibit was the very large number of modifications in the forms of apparatus, having the general object of making it more convenient for the persons using it. Especially interesting were those exhibited by the Société Générale des Téléphones. Among these may be mentioned the desk form shown in Fig. 28, which comprises a whole installation. It is on rollers and may be moved about at will. The microphone forms the top slab of the apparatus, and is slightly inclined; the two telephones are the receivers; the small push button in front is the call (battery call). Another convenient form known as the Berthon form is shown in Fig. 29, in which the receiver and transmitter are connected together by a convenient handle so that the former is at the ear while the latter is at the mouth; the relative positions may be altered slightly by adjusting screws. The call button and switches are comprised in the small wall fixture. This form is used largely for desk work, or on shipboard, or in general, when the person talking can not remain in a fixed position in front of a fixed microphone. In another form the receiver was attached to a long handle which enabled the user to rest his elbow while holding the apparatus. In some of the wall instruments two small ornamental brackets, each having a small cushion, were fixed at the two sides of the apparatus to enable the listener to rest his two elbows while

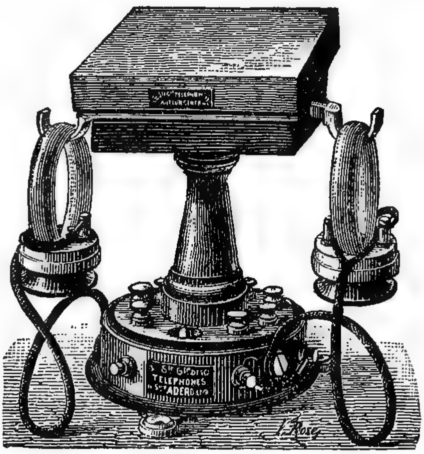


FIG. 28.—Telephone apparatus; by the Société Générale des Téléphones.

holding the two receivers to his ears. In another form the apparatus was accompanied by a small writing tablet for taking notes while listening or talking. In another, the trumpet-shaped ear pieces of the receivers were made of thin soft rubber in place of the usual hard rubber, making it much more comfortable for the listener, for long conversations.

Among other exhibits were complete installations for use on shipboard. These were inclosed in tightly fitting iron boxes, and were especially well insulated against moisture; the switches and calls were so arranged as to obviate the use of a central station, each operator being able to call any other directly.

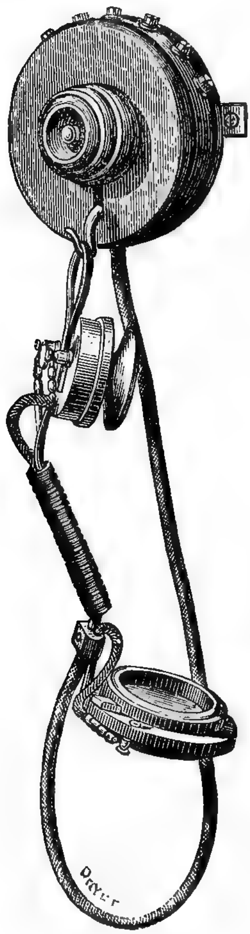


FIG. 29.—Berthon's telephone apparatus.

There were also a large number of exhibits of private telephone systems, such as for domestic purposes, for factories, large establishments, etc., accompanied by the necessary annunciators and calls, to enable one person to call any other directly. In general, there were many exhibits of this kind showing great progress in the adaptability and use of the telephone abroad, progress which can not be looked for here in the United States, the birth place of the telephone, until the broad fundamental patents have expired.

Apparatus for divers.—In the French naval department there was exhibited an apparatus devised by Auger for the use of submarine divers. It consisted essentially of two small telephones united by a curved, flat spring which passed around the head and held the telephones to the ears. To the same spring was attached a microphone, which was thereby held in front of the mouth.

Theatrophone.—The Société Générale des Téléphones exhibited the theatrophone of Marinowicz. This was a somewhat complicated but very complete public telephone receiving station, which was always connected with a transmitter at some musical entertainment. It was operated by dropping a 50 centimes (10 cents) silver piece into a slot, which puts the telephone in circuit. After five minutes the mechanism automatically cuts it out. A company is introducing these in Paris, and provides a continuous musical entertainment at the transmitting station.

Telephonograph.—In the Edison exhibit was shown a telephonograph which consists of an automatically acting phonograph attached to a telephone receiver, for the purpose of recording a telephone message on the phonograph in the case when no one is present to receive it. From this phonograph record it can then readily be reproduced when the person for whom it was intended returns.

Telephonographic transmission.—A different system, though somewhat similar in its object, devised by Lambrigot, will be found described under the heading "telegraph," to which it more properly belongs.

In this connection it may be of interest to call attention to an experiment exhibited at the Franklin Institute, in Philadelphia, in the winter of 1888–'89, by Mr. Hammer, in which a cornet solo was played into an Edison phonograph in New York city; from the phonograph it was transmitted by microphone over a metallic circuit to Philadelphia, where it was received by an Edison motograph receiver and recorded on another phonograph; from this it was then reproduced so as to be audible to an audience of several hundred people in a moderately large lecture hall.

Cryptophone.—The object of the cryptophone, devised by Henry & Berthon and exhibited in the French war department building, is to enable a person to keep watch secretly over a distant building or district. It depends for its action on the vibrating or trembling of the ground or walls of a building caused by a moving object. The cryptophones proper consist of delicate contacts connected to microphones and situated at the respective places. The cryptophonoscope is a sort of annunciator at the receiving station to which the microphones are connected by separate wires. Any vibrations at the microphone cause the respective annunciator to ring an alarm and operate a drop. By means of telephones the watchman can then listen to the nature of the noises. It is applicable chiefly for military purposes.

Telephone bullet probe.—The Western Electric Company exhibited a telephone bullet probe and induction balance, for locating the position of a bullet or other metallic masses in the human body. The apparatus is called Dr. Girdner's, and is said to have been invented by Professor Bell; the balance is known by the name of Hughes. The balance is for the purpose of determining the part of the body under which the bullet is, while the probe is for finding its depth below the skin. A well illustrated, though not very technical, description will be found in the New York Medical Journal, April 9, 1887.

For the electrodynamometer for measuring telephone currents, see "Measuring instruments."

III.—ANNUNCIATORS, ALARMS, BELLS, CLOCKS, GAS LIGHTING, ETC., AND MISCELLANEOUS APPLICATIONS.

ANNUNCIATORS.

Judging from the large number of exhibits of annunciators in the French section, they appear to be coming into use almost as much there as in the United States. Although there were numerous different forms shown, there is little of interest to be described here.

In the ordinary forms of the mechanism of annunciators, the greatest force required by the movable armature of the magnet, is when it is farthest from its magnet, in which position the magnetic force is smallest. This disposition is evidently not the most rational one. In the annunciator devised by Abdank-Abakanowicz and exhibited by Postel-Vinay, this disposition is more rational and therefore requires less battery power. The armature is connected by a spring lever to a small hammer which strikes and trips the signal disk just as the armature is about to touch its magnet; that is, at the moment when its force is a maximum. It has no work to do until the magnetic force is greatest, when the hammer acts by its accumulated impact.

An annunciator for hotels exhibited by the Western Electric Company (United States section) was provided with return calls, by means of which the receipt of every call can be announced to the sender by a return signal to the respective room. The push buttons on the annunciator were furthermore arranged in a circle, and were provided with a common lever arm which, when moved around in a circle, will press each of the buttons in succession. The object of this is to sound a general fire-alarm signal throughout the whole hotel and in each separate room and corridor. This lever arm, being actuated by a strong spring, need merely be released, and will then continue automatically to ring all the bells in succession. The system requires a double circuit for each room.

In several of the annunciators exhibited in the French section polarized armatures turning between two magnet poles were used to turn the signal disks. Reversing the current, by means of a push-button in connection with the annunciator, sets them back again ready for the next call. The chief advantages claimed are that they are less likely to get out of order than those having drops and catches, and that the dials can be reset from a distance. A disadvantage is that two magnets are required for each dial in place of one. Among other annunciators was one in which the number of the call was registered on a counter. In another, called a night annunciator, a small electric light was automatically lit behind the respective transparent dial whenever a call was received.

Fire annunciators.—There were exhibited a number of devices for automatically indicating by an alarm the presence of fire in a building. Most of these were slight modifications of the usual and well-known forms, and are not of sufficient interest to be described here.

Among the simplest was one in which a small spring was held back by a plug of some readily fusible metal, which, when melted by the heat, allowed the spring to expand and thereby to close a contact.

Still simpler and more practical is the form exhibited by J. Hutinet (French section), which consists simply of a double insulated wire composed of two small copper wires very heavily tinned, one of which is insulated from the other by a thin coating of soft rubber, the two together being then wound with cotton, covered with rubber, and an exterior coating of cotton or silk of any desired color to match the papering, drapery, or furniture on which it is to be placed. A fire will melt the rubber separating the two wires, and by virtue of the thick coating of tin will solder the two together, thereby closing a circuit and ringing an alarm. The wire may readily be run through any desired parts of the building without being noticeable, and thereby affords a very cheap and simple protector. It has the disadvantage that it requires the direct action of the flame to actuate it, but this is in many cases no great objection and is partially compensated for by the fact that it can readily be run in any desired parts of a room. It has the additional advantage that it can not, like many others, give a false alarm, and there is therefore no objection to connecting it directly with the fire department of a city. It is less than one-eighth of an inch in diameter and is quite flexible; it is sold for about 1 cent per foot, and is said to require only fifteen to eighteen seconds to fuse the contact between the wires. In mounting it, it may be connected to a small push button, by means of which one can at any time assure themselves of the proper working conditions of the whole system.

Burglar alarm.—Messrs. Chubb & Co. (British section, bronze medal) exhibited a burglar alarm attached to a fireproof safe. The apparatus rings an alarm if the door is opened or if the wires are tampered with in any way, either cut or short circuited. The general principle of the circuit is, as usual, that of a Wheatstone bridge, in which the wires at the contact on the door form one of the arms; any disturbance of the balance of the bridge will ring the alarm, and it will continue ringing until stopped at the bell itself. The constant current for the bridge is said to be very small and requires only one cell; the apparatus is said to be independent of variations in the strength of the current of this cell. A galvanometer needle attached to the apparatus shows whether all is in working order on setting the alarm. Although providing for a number of different cases, it does not appear to cover the case of the bell wires or the battery wires being cut; the battery might be put into the safe, but

the bell must necessarily be outside. For a description, with a good illustration, see Industries, June 14, 1889.

Railroad signals.—This branch belongs more properly to the subject of railroad engineering, and is therefore not included in this report.

References.—For recording and indicating apparatus, see "Miscellaneous applications," below. See also references at the end of the subject of "bells."

BELLS.

Notwithstanding the large number of exhibits of electric bells and appliances, there was little of special interest. Among those differing from the usual forms of bells was an exhibit of Louis Borel (French section, bronze medal), in which the principle was that the contact breaker did not break the circuit until the armature touched the magnet; that is, until the armature had received the full force of the magnet; in the usual form of vibrator this is not the case, as the circuit is broken as soon as the armature begins to approach the magnet. The advantages claimed, and probably justly, too, are that the force is utilized much more completely, or in other words that a smaller battery will do the same work. The armature does not break the circuit directly as usual, nor is it connected to the hammer; it is pivoted so as to be free to move, and when close to the magnet it strikes, with the full force of its accumlated energy, the pivoted hammer, which latter in moving breaks the circuit; this enables the force of the armature to be used in the position in which this force is a maximum. The external appearance of the bell is also of interest as a complete departure from the usual forms. The whole apparatus is in the form of a large acorn, hanging on a pendant from the ceiling or from an ornamental bracket. The upper part of this acorn is the bell proper; the lower part contains the mechanism, the leads being the suspension.

Bonnet (French section) exhibited a bell having two clappers striking it in different parts and thereby producing two different and distinct sounds or signals; by means of a three-point push button these two can be rung together, producing a third distinct signal.

In the electric trumpet devised by Zigang and exhibited by Basśe-Crosse (French section), the bell was replaced by a small vibrating diaphragm at the base of a small trumpet. The armature of the magnet was directly on the diaphragm, which contained also the interrupter. By means of an adjusting screw the pitch of the note emitted may be altered slightly, thereby enabling it to be distinguished from a second one in the same room. It is said to require less battery power, as the energy required is said to be less. The sound is said to be more decided and penetrating, for which reason it is used largely as a railroad signal.

Another call bell of interest, called the "magnetic bell," is one devised some years ago by Abdank-Abakanowicz, and exhibited by Reichmann (Russian section). Its chief point of interest is that it requires no battery. The current is generated by means of a small alternating-current magneto, consisting simply of a permanent horseshoe magnet and a small coil of fine wire, which is fixed to a stiff flat spring so as to be capable of vibrating to and fro between the poles of this magnet. To generate the current all that is necessary is to snap this spring, which is readily done by means of a convenient handle; the coil will vibrate for a few seconds, generating a momentary current every time it passes between the poles of the magnet. The receiver, or bell, consists simply of an electro-magnet, with a polarized armature, which contains the hammer to strike the bell. There is no interrupter, as the current is an alternating one. The whole is of extremely simple construction and is not likely to get out of order. The sizes are almost unlimited. Bells were exhibited 18 inches in diameter, while others are said to have been constructed 3 feet in diameter. As the electromotive force generated is very high (in the small sizes it is said to be about 75 volts), the bells may be at a very great distance. They are used largely for railroad work, as also for telephone calls. Push buttons and door-bell pulls are arranged so as to snap the spring by the action of pressing the push button or pulling the knob of a door bell.

References.—A few other exhibits closely allied to this subject of calls, bells, and annunciators have been referred to the subjects of "telegraphy" and "telephony," where they more properly belong. See, also, "Miscellaneous applications," below.

ELECTRIC CLOCKS AND TIME DISTRIBUTION.

These exhibits belong more properly to the class "Watches and clocks" (class No. 26), in which most of them were exhibited. They will therefore not be described here.

The following notes regarding some of the exhibits may be of interest here. Reclus (French section) gives the following data regarding the battery power used in his clock. The distributing or master clock is wound up electrically, requiring every half minute a current of 400 milliampères for one-twentieth of a second, which makes a consumption of 57 coulombs per day, or 6 ampère hours per year; the Leclanché cells will, therefore, run it about 3 years. The receivers, which are also run electrically, require 125 milliampères every minute for about 1 second, making 180 coulombs per day, or 18.25 ampere hours per year. He states that a good Leclanché can deliver 350 to 400 coulombs per day without sensible polarization. It is therefore not overworked with 180 coulombs output per day. He gives the total capacity of the cells he uses as 90,000 to 150,000

coulombs, and that therefore the cells will run the receivers about 18 months.

In the Gardiner system of time distribution (United States section, Government exhibit), used by the United States Naval Observatory, a master clock sends a momentary current to line at noon every day which sets the hour, minute, and second hands of the independent, supplemental, or controlled clocks exactly to noon, no matter how much they have varied during the previous twenty-four hours. This is accomplished by an ingenious pin and cam motion on the hands, which is actuated by the current, and which moves all the hands to 12 o'clock and immediately releases them again, each supplemental clock being complete in itself. This correcting attachment may be put onto many clocks already in use, and they can be set by merely connecting them about noontime to the many circuits through which this noon current is sent from Washington. It is in practical operation over lines covering more than 50,000 miles of territory, and is said to be the only system accepted and adopted by the United States Government in all the Department buildings at Washington. It is stated also that time is sent from their lines to Spain via Havana.

For a well-illustrated and detailed description of the well-known Hipp's system of electric clock and time distribution in eastern Switzerland (exhibited in the Swiss section, gold medal) see La Génie Civil, March 24 and 31, 1888.

The "Horatéléphone" exhibited by Salvaing (French section, honorable mention) is intended to replace the expensive tower clock in small hamlets and villages, by a small clock which by electrical transmission will strike the hour and half hour (by repetitions of the hour) on any convenient tower bell in a church tower or public building.

GAS LIGHTING.

The exhibits in this class were not numerous, as such apparatus, so very common in the United States, is used very little in France, owing greatly to the fact that gas is used much less in private houses than it is in the United States. Oil lamps are preferred by many, even by the wealthy.

Some ingenious devices were exhibited by Née and also by Giraud (both French). One of them was for lighting a burner by the act of turning the cock. The apparatus was simple and could be attached to any burner, plain or Argand, between it and the end of the bracket. The turning of the cock lights a small auxiliary flame which is long enough to light the main flame, and which is again turned off when the other is turned on full. The objection is that the gas flame can not be turned down partly without causing a leak from this small flame. Also, that in this as well as in other forms

of this device, it is possible, by leaving the cock partly turned, to keep the battery short-circuited, a case which is not possible in the usual American forms. A modification of this was shown, for lighting from a short distance by means of a rubber bulb and small flexible tube, the air pressure from which turned the cock by means of a small piston forming part of the mechanism.

Reference.—For electrical ignition in gas engines see "Miscellaneous applications," below.

DOMESTIC APPARATUS.

Numerous minor devices were exhibited for various purposes, chiefly in private houses, but they were mostly either of the nature of playthings, or of little novelty or importance. One of the most common was a small low resistance battery or accumulator conveniently arranged in a box having a contact key, a small spiral of fine platinum wire and a small wax taper touching the latter. On pressing the key the current heats to redness the coil of platinum which lights the taper. From this a candle or another taper can then be lit. These appear to be used largely in France, judging from the large number of exhibits. This may be due to a great extent to the very high price of matches in France.

MISCELLANEOUS APPLICATIONS OF ELECTRICITY.

Under this heading will be mentioned only those applications in which small currents are required, as distinguished from those in which currents of greater quantity are required, and which therefore belong to the same class as dynamos, lamps, motors, etc., which see for such miscellaneous applications. It will be noticed from the following numerous applications that electricity is coming into use very largely and in very many different ways either as a simple substitute for other means which would require very complicated mechanical apparatus, or as an auxiliary means for doing what could not have been done otherwise.

GAS ENGINES WITH ELECTRICAL IGNITION.

The ignition of the gases in gas and petroleum engines by an electric spark appears to be coming into use more generally, judging from the large proportion of engines exhibited in which this way is preferred to the gas-flame ignition. There were exhibited twenty-one different systems of gas and petroleum engines, counting the various different exhibitors of the Otto engine as one exhibit. Of these, thirteen (or 62 per cent) used electrical ignition, and only eight (or 38 per cent) used the gas-flame ignition.

Historical.—The following abstracts regarding the history of electrical ignition are taken from a paper of Mr. Delamere-Debout-

teville, read before the Institution of Mechanical Engineers July 3, 1889. In 1844 John Reynolds used a platinum wire heated by means of a battery. A mechanical contact maker and breaker started and stopped the current at the proper moment. In 1850 Shepherd used an electro-magnetic generator in place of a battery. In 1857 Barsanti and Mattenni used a Bunsen battery, with a de la Rive multiplier, the sparks from which were used. In 1860 Lenoir replaced the de la Rive multiplier by a Rhumkorff induction coil. The primary current passed continually, and the secondary was closed when the spark was required. There was difficulty in timing the spark exactly.

General.—The heated platinum wire is apt to become cooled at the moment of the passage of the gases, and it can not be timed sharply, besides requiring considerable battery power. It therefore seems to be abandoned. All the engines exhibited used the spark. The chief advantages of the spark over the gas flame appear to be its very high temperature, which is of importance, especially when poor gases are used; it is independent of cold or moist air; it reduces the temperature of the valve chest and parts, and thereby facilitates lubrication of those parts and does away with incrustations formed there; in some of the systems it can be very definitely timed, which is claimed to be very important, as there is said to be a considerable difference in the power if the time of ignition varies one-twentieth of a second. The disadvantages of using electricity in place of the gas flame depend upon the particular system used; in general it introduces something with which the ordinary mechanic is not familiar.

Classification.—The systems exhibited are here divided, for convenience, into four classes. All, in common, use electrical ignition only, having no means for gas ignition, showing that they can rely entirely upon the spark. In all but one the spark is made to pass in the cylinder; in the other it is in a special chamber. The insulation of the parts entering the cylinder are variously of porcelain, plaster of Paris, or asbestos, in order to stand the heat and the mechanical pressure of the explosions.

First system.—In the first system a battery, generally two or three large Bunsen or bichromate cells, is used with an ordinary Rhumkorff induction coil having a simple hammer vibrator; the vibrator acts all the time while the engine is running, and the spark of the secondary coil is operated by various means. In all of these the spark passes between two *fixed* points in the cylinder. The advantages of this system over some of the others is that there are no moving parts entering the cylinder; that there are numerous sparks generated instead of a single one, as in some of the others; and that the spark can be well timed. The disadvantage is that the vibrator

acts all the time, which is bad for the contacts of the vibrator, and consumes battery power continually.

Details.—In the engine exhibited by E. Roger (French section) the secondary circuit is normally open at a sort of switch outside of the cylinder, which is operated by the moving parts of the engine, and is closed the instant the spark is required for the explosion. When the switch is closed the only break in the secondary circuit is in the cylinder, where the sparks are therefore produced. It is evident that no premature explosions can take place.

In the engines of Louis Charon and those of Solomon Frères and Tenting (French section) the secondary circuit is continually short-circuited outside of the cylinder, except the instant when the spark is required. Premature explosions can not take place unless this short-circuiting switch is exceedingly dirty. They used two large cells.

Those of Thomas Powell (French section) differ essentially from the others, in that the spark passes continually in a spark chamber, which is closed by the slide valve. When ignition is to take place a port in the slide valve makes this spark chamber communicate with the cylinder, thus igniting the gases. The length of the spark is 1.5 millimeters, or about $\frac{1}{16}$ inch. They claim that the instant of ignition can be more accurately and definitely timed by these ports in the slide valve. There is probably more possibility of premature explosions, as in the flame-ignition engines, causing it to "sneeze." They use only one cell of two carbon plates in bichromate solution, the zinc being in sulphuric acid in a porous cup.

Second system.—In the second system a battery and induction coil are used as before, but the primary circuit, instead of the secondary, is closed when the spark is required. The vibrator, therefore, acts only while the primary circuit is closed, thus economizing battery power. It has the same advantages as the first system, except that the spark is not so definitely timed, and is not so sure, as it is necessary that the vibrator starts itself and responds promptly; to do this it must be well adjusted, and its contact must be very clean; it is difficult, if at all possible, to clean it while running.

To this class belong the engines of the Société des Moteurs à Gaz Français, A. F. Noel (French section), and of the Société Anonyme des Moteurs Inexplosibles au Pétrole et au Gaz (Belgian section). In these the primary circuit is operated by a contact piece on the shaft or other moving part, and a brush sliding thereon, usually made adjustable in order to time the spark. The one exhibited by Rouart Frères et Cie (French section) was a double-cylinder engine, and in addition to the above there was a second contact piece on the revolving shaft connected to the secondary circuit, and having two brushes, the object of which was to switch this secondary circuit

alternately to each of the two cylinders. They used only two large one-gallon bichromate cells. The frame of the engine was used as a ground-return circuit for both the primary and the secondary currents.

Third system.—In the third system a magneto machine is used to generate the spark without an induction coil. The armature of the magneto, usually a simple Siemens H armature, is kept from revolving by a strong spiral spring. For each explosion it is revolved on its shaft through 90 degrees against this spring and allowed to snap back to its normal position, during which rapid return motion it generates a momentary current. An instant after the armature is released, and at the moment when its current is a maximum, the circuit is broken in the cylinder, producing there a single bright spark. The advantages are that no battery is required, there is no coil with a vibrator to keep in order, and it is always ready to start; as the high rate of rotation necessary to generate the current is produced by a snap movement, no great speed of the engine is required at starting, as would be the case if a dynamo was used in place of a magneto. A disadvantage is that only one spark is produced in place of a number of them as in the other systems, but as it is a much more powerful spark, and quite positive, this does not appear to be an objection. In this system there must be moving parts entering the cylinder to break the current there.

The engines of Gotendorf & Co. and of E. Delahaye (French section) were of this class. In the latter the exact time of the spark may be adjusted by a cam movement. The engine of W. C. Horne (British section) also belongs to this class. It differs from the other two in that the H armature is normally in the stable position into which the magnets would pull it, the spring assisting it to return to this position, while in the other two the normal position is the unstable position, in which it is held against the magnetic pull by the spring, which must, therefore, necessarily be much stronger. The spark is produced between two steel springs in the cylinder, operated by means of a rod passing through a stuffing-box. This rod has a rotary notion instead of a longitudinal one, thereby facilitating the construction of the fireproof stuffing-box.

Fourth system.—In the fourth system a dynamo or magneto is turning all the time, generating the current, which is broken in the cylinder directly without a Ruhmkorff coil. The disadvantages of this system are that in starting the engine sufficient speed must be produced by hand before the dynamo will generate sufficient current to produce a spark.

In the engine of E. Durand (French section) a small, simple magneto is used, generating an alternating current. Both wires are insulated; that is, the frame of the engine is not in circuit. The circuit is broken in the cylinder by a revolving rod, as in the engine of Horne. No self-induction coil is used.

In the Baldwin Gas Engine (United States section) the current is generated by a small shunt-wound dynamo of about one-eighth horse power. It is driven directly from the fly wheel by a friction pulley, the pressure being produced by its own weight. There are two friction pulleys of different sizes. The smaller one, for high speed, is used only for starting. There is a self-induction or spark coil in circuit, and the circuit is closed except when the spark is required. The breaking of the circuit is operated by an insulated pin passing into the cylinder and having a longitudinal motion. It is difficult in this arrangement to keep the contacts in the cylinder clean, especially as the tendency of this particular construction is to destroy its own contact.

MINE BLASTING.

There are two classes of electrical mine blasters—the low-tension class or those in which the ignition is caused by a heated wire, and the high-tension class, in which it is caused by a spark. A special commission appointed by the French Government in 1888 to examine the matter of mine blasting reported that there were important objections to the high-tension caps, and that they recommend the use of those of low tension. The chief objections to those of high tension are the following: The impossibility of exploding the caps unless the leads are perfectly insulated, the difficulty of making them all alike, and the danger of igniting the fire damp should there be a leak from the wires.

Among the exhibits of the low-tension class was one of Manet (French section). The chief advantages claimed are the simple and solid construction of the caps, their cheapness, and the fact that they are all absolutely the same by virtue of their construction, which is entirely by machine. The caps are of a glass tube containing the chlorate of potash powder (not gun cotton), and closed by a wooden plug through which pass two metallic pins, to the inside ends of which is soldered a fine platinum wire 0.377 inch long and one-twentieth of a millimeter (0.00197 inch) diameter; the leads are connected to their pins; the resistance of a cap is 3 ohms; they appear to require from one-third to two-thirds of an ampère. The exploder is a small hand dynamo weighing only 22 pounds; the size is only about 10 by 8 by 8 inches. It has an electromotive force of about 80 volts. It is a self-exciting series machine, and is turned by a crank and a train of four gear wheels. An automatic switch attached to the dynamo will switch the current into the external circuit the moment it has reached the proper strength. It is able to explode eighty fuses without a line resistance, or twenty with a line resistance of 4 ohms. The line resistance is proportioned so that the total external resistance is the same, namely, 64 ohms for any number of fuses up to twenty. The diameter of the leads must

therefore be chosen in accordance with the distances, which is a feature not without its objections. The advantages of the dynamo are that it is independent of the state of the atmosphere, and its current is always exactly the same. The dynamo includes a bell-testing appliance, by means of which the continuity of the circuit may be tested before proceeding with the explosion.

Burgin (Swiss section, bronze medal) exhibited a small and very conveniently arranged hand dynamo for the same purpose, with the addition of a switch by means of which either a high-tension spark or a low-tension current can be produced by different internal connections of the dynamo. The dynamo is automatically switched onto the circuit at the proper moment by a magnet in the main circuit. A cap was exploded in the presence of the writer through the joint resistance of four persons in series joining hands.

Breguet, Ducretet, and others exhibited mine exploders of the old form of a steel magnet with soft-iron pole pieces surrounded by coils, the spark being produced by a sudden tearing off of the armature produced by a blow with the hand. Scola & Ruggieri (French section) exhibited one of these with the additional improvement that the soft-iron cores were laminated, by which the induction and therefore the capacity of the apparatus was increased.

ELECTRIC ORGANS.

Historical.—The first application of electricity to musical instruments having a keyboard is said to have been conceived more than one hundred years ago by a priest from Nivernais, named Jean Baptiste Laborde, but how it was to be applied the record unfortunately does not state; it was, presumably, a mere vague prophecy. The real history appears to have begun in 1867-'68, when an Englishman named Barker, aided by a barrister named Peschard, constructed the first electric organ in the church of St. Augustin at Paris. The principle appears to have been simply to open the valves of the organ pipes by electro-magnets the circuits of which were closed by contacts at the keyboard. This did not prove very satisfactory, owing to the large battery power required, not only in the number of cells, but also in their capacity.

To overcome this important objection Messrs. Schmoele & Mols, of Philadelphia, devised an ingenious relay system, called the electro-pneumatic system, in which the function of the electro-magnets was not to open the valves themselves but merely to open a small aperture under the valves, which admitted the compressed air used to blow the organ, which in turn opened the valve; thus the force required by the magnets was very small, the actual work of opening the valves and moving the mechanism for the different stops being done by the compressed air with which every organ is already supplied.

General.—In general in an electric organ there is a contact connected with each key and stop of the keyboard, and a wire for each leads the current to the respective pipe or stop mechanism and actuates electro-magnets there, which in turn operate directly or indirectly the pipes and stop mechanism. The advantages of electric organs over those operated by purely mechanical means are as follows: The only connection between the keyboard and the pipes being by means of electric conductors, the keyboard and the pipes may be placed any desired distance apart, and either of them may be placed in any convenient part of the church or building, irrespective of where the other is placed; the same keyboard may also be used for several different organs, separately or together, by means of a simple switch putting the battery on either one or the other organ or both together; or there may be several keyboards for the same organ; the keyboard may be moved about, being connected merely by a flexible cable. This electric conductor takes the place of and dispenses with all the complicated levers, pins, wires, and angle pieces, which are otherwise necessary to connect the keyboard with the pipes and which, being very complicated, are apt to get out of order and to be affected by moisture, dryness, and dust, causing variation in their action. The force required by the player in depressing the keys and moving the stops, being merely to close a small contact, is practically nothing. The keyboards, stops, etc., can be brought into as small a compass as desired, thereby making it easier for the player.

Organ exhibited.—There was only one electric organ at the exhibition. It was exhibited by Messrs. Merklin & Co. (French section), and made in accordance with the patents of the American inventors, Messrs. Schmoele & Mols. The organ proper was in two parts, placed at the two ends of the upper gallery, while the single keyboard was in the center of the main floor below. The system was that called the electro-pneumatic system mentioned above.

Valve mechanism.—The mechanism for opening the valves and for working the mechanism of the stops may be briefly described as follows: The valve is attached to the movable part of what might be termed a small pair of bellows directly below it, and in the same compressed air chamber. The compressed air normally presses on both the inside and outside of this bellows, and, therefore, does not actuate it. The action of the electric magnet is simply to open a small aperture of this bellows, allowing the inside to communicate with the open air; the pressure of the compressed air on the outside of the bellows consequently closes it, and being attached to the valve of the organ pipe, it pulls it open, forming with it a sort of balanced valve. The force required by the electro-magnet is therefore very small; the armature weighs only a gram (15 grains) and

its movement is only 1 millimeter ($\frac{1}{25}$ of an inch). All the mechanism of the stops, no matter how heavy, is actuated in the same way by a sort of bellows, larger in proportion to the work they have to do, and controlled electrically by a very small magnet.

Contacts.—As the current used is very small the contacts may be made very simply. They consist of small, flat springs of German silver, which are attached to the lever of the key, and slide over a fixed contact piece, thereby cleaning themselves each time they move. In the older systems of electric organs in which the valves were opened directly by the magnet, the currents necessary were so great that the contacts had to be made with mercury cups and wires dipping into them.

Battery.—Five Lalande & Chaperon cells are said to be sufficient for a large organ and will not need attention more than once in several years. In one of their organs at Lyons four of these cells were used; the box containing them was not opened for three years, during which time they did not fail once. The cost of recharging them is very slight, amounting, it is claimed, to only 40 to 60 cents a year.

Cost.—The cost of these electrical organs is stated to be the same as that of mechanically operated ones.

MELOGRAPH AND MELOTROPE.

Carpentier (French section, gold medal, for this exhibit alone) exhibited in the class of musical instruments a set of instruments called melograph and melotrope. The object of the former is to make an accurate and permanent record of what is being played on a special piano. The object of the melotrope is to mechanically reproduce this music on any other piano from the record of the melograph or from duplicates of the same. The melograph operates electrically as follows: A contact is secured to each key of a piano; these are connected by wires to the melograph proper, which consists of a corresponding number of electro-magnets, operating a set of ink-writers, which record a series of parallel broken lines. The relative positions of the lines of this record, therefore, indicate the pitch of the notes, and the lengths of the lines indicate the time or length of the note. For a range of three octaves, or thirty-seven notes, the record is a band of paper, about 4 to 5 inches wide, having room for thirty-seven parallel lines. This band of paper is made to pass through the melograph or ink-writer at an absolutely constant rate of speed by means of a small electric motor and an ingenious mechanical regulator. From this melograph record any number of duplicates are then made, in the form of a band of stiff, tough paper, with rectangular holes punched through them, corresponding in position and length to the marks on the original record. These duplicates are sold in the market and are ready for use in the melotrope. The latter is a small rectangular box, placed over the keyboard of

any piano; it is operated by a crank and fly wheel and strikes the keys by means of pins. The perforated band of paper is passed in at one end and out at the other. Its operation is purely mechanical, and therefore does not come within the scope of the present report. For a very good and fully illustrated description of the whole set of apparatus, see La Lumiere Electrique, Vol. XXVI, 1887, No. 53, p. 651.

AUTOMATIC WEIGHING MACHINE.

Among the weighing machines was one called the Spelgrove electric weighing machine, exibited by Messrs. W. & T. Avery (British section), in which the operation of adjusting the sliding weights on the steelyard or beam was performed automatically by electrical means. The object of this machine is to combine the accuracy, reliability, and great capacity of the lever or beam scale with the self-indicating advantages of the spring balance. All that the operator needs to do is to place the objects to be weighed on the platform of the scales and read off the numbers on the dials when the steelyard has come to rest.

As the construction of the automatic apparatus for adjusting the weights is very complicated and intricate, perhaps more so than is necessary, nothing more than a general description of the principles of this operation will be given here. In Engineering, June 21, 1889, there are some good working drawings of one of these scales, differing only slightly from the one exhibited; the description, however, is not very clear.

The general construction of the scale is that of the usual platform beam scales, having two sliding weights, one small and the other large. The whole of the operating mechanism is on the beam itself. This is an essential feature. At the free end of the beam, in place of the usual stops for limiting its movements, are two electrical contacts, one above and one below the beam; closing the upper one causes the weights to advance on the beam, the lower one causes them to recede. One or the other of these contacts will therefore always be closed as long as equilibrium has not been reached, and the mechanism will not come to rest, even if it has made a mistake, until the beam rests between the contacts, when equilibrium has been reached. In a scale for 500 kilograms the small weight will adjust itself in steps of one-half kilogram up to 10 kilograms, and the large weight in steps of 10 kilograms up to 500. The adjusting weights are pushed forward by a small fixed electric motor on the beam. They are brought back by springs. In placing the goods to be weighed, for instance 86.5 kilograms, on the platform, the beam will move up and close the upper contact. This starts the motor, which pushes the small weight out to the extreme end, registering 9.5 kilograms. On arriving at the end of the beam it closes another contact which causes the large weight to be pushed

out in steps of 10 kilograms, until overbalance is reached, which in this case would be at 80, therefore registering altogether 89.5 kilograms. This causes the beam to tilt and to close the lower contact. This in turn relieves the small weight, which moves back by a step-by-step escapement until exact balance is reached at 6.5 when the beam will rise, open the circuit, and rest between the two contacts. On taking off the load, the beam falls and closes the lower contact, which releases the small weight, which, when it arrives at zero, closes a contact there that releases the large weight. It will be seen from this, that should the machine make a mistake by moving the large weight too far, the automatic action will be to bring both back to zero and make them start over again from the beginning. The weights can not come to rest until equilibrium has been attained. A weighing is stated to require from six to twelve seconds, while two to three seconds are required for the return of the weights to zero. For ordinary intermittent work, a battery of large Leclanché cells is said to be sufficient.

A number of difficulties in an electric scale of this sort are overcome by the ingenious idea of making the small weight move first, to the extreme end of the beam, then moving the large weight out to overbalance, and finally moving the small one backwards to the required position. This operation is the reverse of the natural one in adjusting by hand.

Scales weighing up to 1,000 pounds adjust to a pound, that is, to one-tenth of 1 per cent. Those for 40,000 pounds adjust to 8 pounds, that is, to two-tenths of 1 per cent.

While the machine in its present form is probably too complicated to come into use very largely, the principles are good and will doubtless admit of a simpler construction.

MACHINE FOR AUTOMATICALLY WEIGHING OFF AN EXACT AMOUNT OF YARN.

The object of the machine is to weigh off rapidly and with precision an exact predetermined amount of yarn and to wind it into balls or otherwise, in the form in which it is to be sold. It was exhibited by Mouchère, in the French section, in Class 54 (Appliances and Methods of Spinning and Rope Making).

It consists essentially of a pair of scales, an apparatus for feeding the yarn on to the scale pan, an apparatus for stopping this feed at the proper time, and a machine for winding the measured amount of yarn into a ball or any other desired form.

The yarn is placed in skeins, as it comes from the spinning machine, upon two reels or rollers above the machine. The thread passes loosely between a pair of smooth jaws like those of a vise; thence between a roller and an idle pulley resting on it, and finally into a light cylindrical box of tin, which is the scale pan of the weighing scales.

By means of a chain gearing and a large wheel this roller is turned rapidly (by hand or by other power) and pulls the thread of yarn off the skein and into the box as long as the idle pulley rests against the roller. The tin box into which the yarn is thus fed is on one arm of a pair of scales, on the other arm of which is placed the required weight. On the weighted end of the scales there is a wire dipping into a mercury cup, thereby keeping an electrical circuit, from a battery or small dynamo, closed, as long as there is not the required amount of yarn on the pan. In this circuit there is a powerful electro-magnet, the armature of which is secured by levers to the idle pulley and vise jaws described above. As soon as the weight of the yarn, which is being fed on to the scale pan, is sufficient to counterbalance the weight on the other arm of the scales, the tilting of the scale beam opens the electric circuit at the mercury cup and thereby releases the armature of the magnet which in turn raises the idle pulley from the feed roller, thereby stops the feed, and closes the vise jaws, which then hold the thread securely at the required point. An empty scale is then put in place of the one which is full; and while the second quantity is thus being weighed off the first is simultaneously wound into a ball by a simple winding apparatus attached to and operated by the same machine.

The success of the machine seems to be due to the fact that the weighing and the winding are not one and the same, but are two successive operations. The precision with which the yarn can thus be weighed depends evidently only on the sensitiveness of the balance used. Instead of opening a circuit when the required weight is reached, the apparatus might be arranged to close a circuit, thus economizing current. But the latter would have the disadvantage that should the current, from any cause, fail it would not render itself evident, as in the reverse arrangement, in which, if the current fails, it stops the feed.

KNITTING MACHINE IN WHICH THE DESIGN IS PRODUCED BY ELECTRICAL MEANS.

Among the weaving and knitting machines was one exhibited by Emmanuel Buxtorf (French section), in which the design, in two colors, was produced by a very simple electrical contrivance attached to the ordinary machines. It is a very good example of a case in which a very simple electrical attachment to a machine will perform an operation which would require a very complicated apparatus to do mechanically, if it could be done at all.

The machine is for making material like that for jerseys, hosiery, etc., which is made in the form of a cylinder, and is woven of a single thread, which is knitted on by a continuous circular movement of the knitting mechanism similarly to the way in which a stocking is knit. The design of two colors is produced by using two threads of the two colors side by side, in place of the single one, being

therefore practically the equivalent of a single thread the two sides of which are colored differently. These are led to the needles side by side, so that one of them hides the other, therefore making one side of the material one color and the other side the other color. By merely interchanging the relative position of these two threads a design of two colors is produced, the one on the back being the negative of the design of the face.

This interchanging of these two threads is effected by means of two light guides, which are moved by an armature of a small electro-magnet, which is attracted or released according as one or the other colored thread is to form the face of the material. The current for the magnet is made or broken by a contact-pin sliding over the surface of a small rotating brass cylinder on which the design has been painted with thick shellac or other insulating compound. Whenever the pin passes over the shellac the circuit is broken. This design cylinder is rotating in exact correspondence with the cylinder of material which is being woven, and also has a corresponding axial motion, so that the position of the contact-pin on the design cylinder corresponds exactly to the place on the material where the thread is being woven into it. The exact place where the threads are to be interchanged corresponds, therefore, to the place where the current is made or broken by the design of shellac on the brass cylinder. By rotating this design cylinder two or three times as fast, the design will be produced in two or three places, respectively, on the material; by increasing or diminishing the axial motion of the design cylinder the design will be shortened or elongated, respectively, on the material, producing quite different effects.

The original design is evidently not limited in any way as to its shape, outline, irregularity, or simplicity. Owing to the nature of the weaving, the color on the back of the material shows through lightly on the face, making the face slightly less definite and prominent.

The operation of weaving a colored thread into such material was done before by mechanical means, but it was limited to geometric patterns, and the mode of weaving in the colored thread rendered the material inelastic.

LOOM ARRESTER.

Among the electrical devices for automatically stopping a spinning and weaving machine when a thread is broken, or in general when any fault arises in the process of the weaving, were a number of devices exhibited by Radiguet, (French section, class 55). The action is, in general, that any fault or failure in the weaving will cause a contact to be closed which actuates a small, light magnet. The action of this magnet is simply to trip a small lever, which therefore requires only a very small current. The releasing of such lever puts into action a more powerful mechanism, which shifts the belt and stops

the machine. By this means a very small current is sufficient to actuate the necessarily heavy mechanisms. The apparatus furthermore cuts the current off as soon as the mechanism has operated, to avoid waste of current. It is furthermore so arranged that the workman can not start the machine until the fault is repaired. The inventor prefers to employ metallic circuits throughout, instead of using the frame as a return circuit. He seems to have been one of the earliest workers in this field, having begun in 1865. He claims that over 8,000 looms are already fitted with these devices.

TRICYCLE.

Millet (French section) exhibited a tricycle of peculiar construction, with spring spokes and flexible rim, which was operated by a sort of gas motor, the gas being ignited by electricity from an induction-coil and a small primary battery. There was nothing novel or important about the electrical portion of the apparatus.

MACHINE FOR VOTING.

Debayeux (French section, honorable mention) exhibited a voting machine. The voter moves a pointer opposite to one of a vertical list of names and pulls a lever. Nothing more could be ascertained about the exhibit.

ELECTRIC LOCK.

Piret and also Lémonon (both French) exhibited an electric lock for a door, which enables the door to be opened from a distant point by a push-button. It is an attachment to replace the metallic part on the jamb of a door, into which the bolt of the lock passes, and can therefore be adapted to any existing lock without changing the lock itself. An electro-magnet trips a lever which opens the side of this catch, enabling the end of the bolt to pass out through the side unobstructed without withdrawing the bolt of the lock. A spring pushes the door open slightly. It is for use in public buildings, as for instance for the exit doors of factories or prisons, the fire exits for theaters, etc. Also for the front door of houses divided into flats, etc.

RECORDING AND INDICATING APPARATUS.

Numerous electrical devices were shown for automatically registering or indicating at a distant station various meteorolgical observations, such as temperature, direction of wind, rainfall, etc.; also the level of water in reservoirs, the rise and fall of tides, etc. Such apparatus belongs more properly to other classes, such as meteorology, instruments of precision, engineering, etc., for which see the reports of other experts.

IV.—ELECTRO-CHEMISTRY.

ELECTROPLATING AND GALVANOPLASTICS.

General.—The deposition of thin coatings of metal from their solutions, by electrolysis, practiced on a commercial scale more than thirty years ago, is shown by the exhibits to have reached a very high state of perfection. The improvements made more recently have been chiefly to improve the adherency of the coating, to vary the nature and appearance of the coating, to increase the list of the metals and alloys which may be so deposited and on which adherent depositions can be made, to coat insulating materials, to color with the oxides of metals, etchings, etc. Among those metals exhibited which formerly presented difficulties are platinum, zinc, tin, iron, cobalt, arsenic, black oxide of iron, brass and bronze, as metals to be deposited, and zinc as metal to be coated.

Galvanoplastics, or the deposition of thick, self-sustaining masses of metal, is coming into use very largely on a commercial scale, chiefly for the manufacture and reproduction of ornamental, artistic, or historically interesting metal goods; important among these are the productions of busts, statues, solid silver goods, and reproductions of antiquities, in their original metals, even iron, such as iron armors.

Electro-metallurgical processes, for reducing the metals from their ores, are also being developed on a commercial scale. Among the exhibits in this class were three electrical processes for obtaining aluminum, one for zinc, and one for obtaining pure iron from iron scrap. Other electrical processes belonging to this class included one for making sulphate of copper, one for bleaching, and one for purifying water and liquors.

Exhibits by countries.—With the exception of two of the metallurgical processes, all the exhibits were in the French section. While they were probably not as complete as might be desired to show the full state of the art, yet they were very interesting and showed considerable development.

DETAILED DESCRIPTION.

The following detailed descriptions are confined to a summary of some of the more interesting exhibits. As the processes are in almost all cases kept secret, it leaves little to be described here, more than a mere mention of the principal exhibits.

Christofle.—By far the finest exhibit of electroplating and galvanoplastics was that of Messrs. Christofle & Co. (French section), who were one of the few in the whole electrical section who received the high award of grand prize. They are the oldest and largest house of the kind in France, if not in the world. They have

carried the art to a state of perfection which few if any others have reached.

Their exhibit of reproductions of works of art and antiquities in their true colors and metals, by electro-chemical means, was one of the most interesting portions of their exhibition and appears to be their specialty. Among their exhibits of reproductions were life-size statues of copper; others of bronze and other metals and alloys; solid silver ornaments and articles; old steel armors reproduced in iron directly; and many other articles, from the most delicate to large and massive pieces. Among the exhibits of electroplating were samples plated with almost all known stable metals and a number of alloys of shades of many different tints. Samples of etching, oxidizing, coloring by oxidizing, aging, and other effects were also shown. Another process of interest is that of superficially bronzing a copper statue by plating it with a coating of zinc or tin and then heating it, whereby the zinc or tin will alloy with the copper, forming brass or bronze on the surface.

Their process of making a hollow reproduction in copper of a bust, in one piece—that is, without a joint—was shown in detail. The mold or cast of the original is made of gutta-percha and forms the retaining vessel for the solution; the anode is a thin foil bent so as to be roughly the form of the inside, but considerably smaller. This anode is of lead, not of copper, the metal which is deposited being that obtained from the liquid only, which must therefore be renewed. In the silversmith department they had a beautiful exhibit of very artistic solid silverware made electro-chemically. Such processes of making ornamental solid silverware have a number of advantages over shaping by hand, giving exact reproductions of the original and being quite rapid and cheap. They have made many copies or facsimiles of historical antiquities from the originals, and with their true appearances, for museums and art schools.

Other exhibitors.—There were besides Christofle a number of other exhibitors of articles of this class of more or less importance.

C. M. Rivaud (French section, bronze medal) had a fine exhibit of ornamental work and of depositions of the precious metals on insulating substances, such as glass ornaments, agate handles, vases, etc., on which the metal, silver for instance, was deposited as a thick layer and afterwards carved away in designs, leaving the metal as a decoration on the glass, it being secured to the glass by virtue of its shape, as a band, for instance.

L. Magniny (French section) exhibited a large number of articles of vegetable, animal, and other insulating substances, electroplated for preserving them or for ornamentation. Among these were natural flowers, leaves, mosses, grasses, insects, laces, ribbons, hats, plaster statues, wooden furniture, wicker baskets, and many other interesting and more or less useful articles. Some of these materials are

very difficult to plate, not only on account of getting the first metallic coating on the insulating substances, but also because many of them are apt to swell and warp when in the bath.

G. Bajou (French section, silver medal) had a fine exhibit of aristic decorative work, including depositions of different colors of alloys, oxidations, frosted finish, etching, inlaid work of different colored metals and enamels.

Claude Lionnet (French section, silver medal) exhibited a large copper statue, once and a half life size, made by electro-chemical deposition; also negatives, in the form of rollers, of ornamental leathers for pressing imitation leathers.

A. Gaiffe (French section, silver medal) exhibited articles electroplated with cobalt, nickel, old cobalt, and old nickel. The cobalt resembles very much the more usual nickel, but is said to have some other properties. The old nickel and old cobalt finish presents a very fine appearance.

J. Pérille (French section, silver medal) exhibited nickel-plating on iron and steel direct by a special process. He uses anodes of nickel perforated with numerous large holes, whereby it is claimed the anode is dissolved better.

Iron oxide plating.—Among the novelties which may be of considerable importance is a process exhibited by A. de Meritens & Co. (French section) for electroplating with black oxide of iron, on iron and steel goods, such as rifles, revolvers, and many other articles. It forms a very hard, black, glossy coating, which, being already oxide of iron, does not rust, and forms an excellent and ornamental coating. The promised description of the process was not received by the writer; it is probably a deposition and not an oxidizing at the expense of the metal, and it is said to be a rapid process. From a theoretical standpoint it is a far better coating for iron than nickel-plating is, as the latter, by its electro-chemical affinity, increases the tendency to rust should the iron be slightly exposed.

Plating without current.—A. A. L. Levy (French section) exhibited articles, such as steel pens, beads, buckles, and other small, cheap metal goods, nickel-plated directly by simple immersion in a hot nickel solution without an electric current. The process is exceedingly simple and rapid, and the coating of nickel, though necessarily very thin, is bright and tenacious, and requires no burnishing.

Plated zinc.—Henry & Co. (French section, silver medal) exhibited articles in which various metals and alloys were deposited on zinc directly, which was said to have been difficult to do formerly.

Accessories.—Delval & Pascalis (French section), who are the successors of Roseleur, who is well known for his work in electrochemistry, had a large and fine exhibit of goods for electroplaters. Among other accessories was an apparatus in the form of a pair of balances, by means of which spoons, forks, etc., were suspended in

the silver bath, and which opened the circuit automatically when the required weight of silver had been deposited. Another apparatus of interest was a copperplating bath, for armatures, which constituted its own battery. It consisted of a bath of sulphate of copper, in which was placed a porous cup containing a bar of zinc in dilute sulphuric acid. The article to be plated was suspended in the copper bath and connected to the zinc; this forms a short-circuited battery, the current of which deposits copper on the article immersed.

MISCELLANEOUS.

COLORING ELECTRICALLY.

Frederic Weil (French section, gold medal) claims to be one of the earliest to have copperplated iron and steel directly on a commercial scale and to electroplate with other metals. He claims to have been one of the first to have used the dynamo in electroplating. His processes are, however, mostly old and already well known. His exhibit was chiefly of articles electroplated with the lower oxides of copper, producing very brilliant colors, chiefly blue, green, red, and yellow. The colors are bright and clear, the process being used chiefly for ornamentation. Articles of any metal or alloy, even iron and steel, may be thus colored directly and very rapidly at ordinary temperatures and in a single bath. Any one color or a variety of colors on the same piece can be produced at will. It is stated that the coating is not exceedingly thin, as is often supposed, and as is the case with the lead-oxide coloring. This may be shown by the fact that if an article thus coated by his process is treated with nascent hydrogen the coating is converted into metallic copper, which has the true color of copper, and can not, therefore, be very thin.

REPRODUCTION OF ENGRAVINGS.

P. E. Placet (French section, silver medal) exhibited what may become an important advance in making plates for printing from pictures, photographs, engravings, etchings, etc. It is a direct process, reproducing all the so-called "half-tints" of photographs, and requiring absolutely no engraving or "touching up" by hand. The process is, to a great extent, secret, but in general the illustration is photographed on a gelatine plate, which is then exposed to the action of light and other similar treatment (etching, we believe), which leaves it with the illustration raised or depressed. On this is then deposited electrically a negative of a thick coating of copper, from which may be printed directly. The prints shown were very beautiful reproductions, and were remarkably perfect in the minutest and most delicate details. The process is termed gravure hiliographique.

ELECTRICAL PRODUCTION OF SULPHATE OF COPPER.

An interesting process, for which great expectations are held, is one exhibited by Messrs. Perreur-Lloyd et Fils (French section, bronze medal), for the manufacture of sulphate of copper by an electrical process in which electricity is produced as a by-product and may be stored and sold. The process is simply a battery in which metallic copper and sulphuric acid are consumed in discharging, forming copper sulphate as a residue. The cell consists of metallic copper in sulphuric acid, forming the negative pole plate, not the positive as usual; the positive pole plate is a plate of carbon in a porous cup containing nitric acid. On discharging the cell the action is as follows: The copper is dissolved, forming copper sulphate; the nitric acid is reduced to nitrous oxide (NO) which is set free as a gas; in order to regain this nitric acid the gas is led through chambers containing fragments of coke and filled with steam and hot air, by which it is again oxidized to nitric acid, which is then used over again. Theoretically, therefore, all that is consumed is copper, sulphuric acid, steam, air, and some heat, while the products gained are sulphate of copper and electricity. But in practice there will probably be other losses. The quantity of electricty developed is, however, comparatively great; for instance, for every pound of copper dissolved there are 385 ampère hours of electricity generated; the electromotive force is said to be 1 volt, and the useful difference of potential may then be about 0.5 volt, at which rate 192 watt hours are generated for every pound of copper dissolved, which corresponds to 0.388 effective horse-power hour per pound of copper, or about 2.6 pounds per effective horse-power hour, or about like coal used for a steam engine. Owing to the low voltage, however, it requires a large number of cells to develop a sufficiently high voltage to be used directly. It is intended probably for charging accumulators in multiple arc, but even then about five cells would be necessary for charging a single set of accumulators all in multiple arc. The retaining cells are made of lava, being cut out of a solid block, which is said to be necessary, as the cells must be heated to about 160° F. and must stand the action of the hot acids at this temperature. It is claimed that the process is much cheaper than the present method of making sulphate of copper. It appears to have been started only quite recently on a commercial scale.

BLEACHING.

The Hermite electric bleaching process was exhibited by Patterson & Cooper (British section), and by Darblay Père et Fils, paper makers (French section). The process consists essentially of electrolyzing a solution of chloride of magnesium, which, by direct decomposition and attending chemical reaction, produces at the positive electrode an oxide of chlorine which remains in solution in the

liquid, forming, it is said, hypochloric acid, which is a powerful bleaching agent; hydrogen is liberated at the negative pole. This liquid is then used to bleach the materials, which reaction simply reduces this hypochloric acid; there is, therefore, no consumption of the chemicals and the same liquid may be used over again repeatedly. The process is a continuous one; the 5 per cent solution of chloride of magnesium is passed through the electrolytic bath continuously; from there it passes through the bleaching bath, from which it is then pumped back into the electrolytic bath. The only loss is the liquid which is retained mechanically by the bleached material, and which is said to amount to from 6 to 10 per cent in twenty-four hours. The electrolytic bath consists of a galvanized iron tank having a perforated supply pipe at the bottom and an overflow pipe for the electrolyzed liquid at the top. In this tank there are a large number of parallel plates, alternately positive and negative. The former are made of thin sheets of platinum in frames of hard rubber to stiffen them; the negatives are round disks of zinc, which are kept revolving slowly and have scrapers attached to clean any deposits which may form on them; these zinc plates, being the negative poles where the hydrogen is liberated, are of course not dissolved. The current used for each bath is from 1,000 to 1,200 ampères, and the potential from 6 to 7 volts, requiring, therefore, about 10 to 12 horse power. The makers guarantee to bleach as much per twenty-four hours with one apparatus as can be done with 100 kilograms (220 pounds) of chloride of calcium. In a published estimate of the relative costs of the old and new method, it is stated that to do the same bleaching as with 1,000 kilograms (2,200 pounds) of chloride of calcium at 230 francs ($44.50) requires power and involves a loss of liquid corresponding together to 102 francs (about $20), making the total cost of the latter less than one-half; this does not, however, include interest and amortization. It is used for a number of purposes, chiefly, it appears, for paper bleaching; it is stated to be capable of bleaching materials which can not be bleached by the ordinary process, as jute, for instance. It is already in use in a number of establishments among which are several in Boston. Very good and well illustrated articles on this process may be found in La Lumière Electrique, Vol. XVIII, 1885, Nos. 48 and 52; also Vol. XXXI, 1889, No. 4; also Revue Internationale de l'Électricite, 1889, Vol. VIII, No. 88, p. 144.

TREATMENT OF LIQUORS.

In the exhibit of A. de Meritens & Co. (French section) there was shown an apparatus for treating water, wines, beers, and other liquors with an alternating current, for the purpose of purifying them by destroying all living organic matter contained therein. It consisted of a row of vertical tubes connected at their tops and bottoms

in such a way that the liquid enters at the first and flows through each in succession. In these tubes are numerous perforated plates an inch or two apart, which are alternately connected as positive and negative electrodes. These are attached to an alternating-current machine. The alternating current, therefore, traverses the liquid repeatedly while the liquid is flowing through these tubes. It is claimed that this treatment will destroy all living organic matter and that the liquid thus treated will not spoil. Two dishes were shown in which some liquor before and after treatment had been allowed to evaporate to dryness. In the former there was quite a large quantity of mold, and in the latter merely a stable sediment of a fine powder.

ELECTRO-METALLURGY.

In electro-metallurgy there were the following exhibits: Létrange & Co. (French section) for obtaining zinc; Bernard Frères (French section) for aluminium by the Minet process; Société Anonyme pour l'Industrie a l'Aluminium (Swiss section); Cowles process for aluminium (United States section): Placet (French section) for refining iron by electro deposition from its solution. The latter operation, the inventor claims, can be done for 1.3 cents per pound; he suggests using such iron for the manufacture of steel by fusion with cast-iron, and for other purposes in which pure iron is required. As all these metallurgical processes belong more properly to the department of metallurgy rather than to electricity, the reader is referred to the report on that section.

PRIMARY BATTERIES.

GENERAL.

Among the very many exhibits in this class were a number of improvements and modifications which were of interest and showed some, though not very great progress. The field being already so thoroughly studied, leaves little room for any very great progress; that shown was mainly in details of construction and in slight, though not unimportant, improvements in the elements of the cells.

The exhibits of powerful batteries showed that electric lighting from primary batteries is not only possible but also practicable; but even at its best it must still be considered a luxury on account of the expense, though if all of the facts and figures given by one of the exhibitors are correct, it has been reduced to the very low cost of one-tenth of a cent per candle per hour, for labor and for material consumed; or two-tenths of a cent per candle hour, including everything. Although this is still between three and four times the cost of gas, yet it makes electric lighting by such means practicable for domestic purposes.

The very thorough researches of Renard are of some interest, resulting in his obtaining what is undoubtedly the lightest battery made. Most of the improvements in batteries were in the details of construction; the only one differing essentially from the old well-known types is the Lalande and Chaperon. In the Leclanché type the tendency appears to be to diminish their resistance, to cheapen the construction, and to diminish the attendance required by them; in the latter direction the so-called dry cells are among the chief improvements. The Daniell cell was conspicuous by the absence of any improvements; with the exception of Callaud's well-known improvement of employing gravity to separate the solutions, it appears to have originated as an almost perfect cell.

Processes for purifying zinc, and for the utilization of the residues of batteries are also being developed. One of the interesting novelties was a battery in which the electricity is a by-product, the object sought for being the residue, namely, sulphate of copper.

Conspicuous by their absence were the inventors so often met, who claim to obtain more energy from their batteries than is possible under theoretically perfect conditions. This alone is a proof of progress.

Exhibits by countries.—The exhibits of primary batteries were almost exclusively in the French section, the only exception of note being by one English exhibitor.

Classification.—Owing to the diversity of applications of the different cells no classification will be attempted here, other than that those usually intended for great power will be described first and those for small currents last. Such a classification is, necessarily, only a very general one. Those of the first group are almost exclusively improvements and modifications of the bichromate of potash type of cell, and the latter of the Leclanché type.

BICHROMATE OF POTASH CELLS AND THEIR MODIFICATIONS.

The Gendron cell (French section, bronze medal) is a zinc-carbon couple, with porous cup. The construction presents some points of interest, the object being to obtain great surface of electrodes, small distance between the plates, small quantities of liquid, renewed continually and automatically and kept in continual circulation. The battery is intended to be used for lighting and for small powers.

Details.—The jar is a low, rectangular box made of sheet iron, covered on the inside and outside with hard rubber, which renders it perfectly acid proof, while the box is light and strong. The porous jar is a narrow vessel with parallel sides, bent around parallel to itself repeatedly, somewhat like a broad, short letter **S**, the long parts of which (seven in number) are straight and parallel, forming practically several narrow porous cells communicating with one another so as to act as one, there being narrow parallel spaces

between each two for a carbon plate. The porous cup has a hole at the bottom over a corresponding one in the jar, with a cock of special construction to drain off the liquid.

Zinc plate.—Each of the seven zinc plates is made of a number of rectangular pieces of thin sheet zinc, well amalgamated and afterward secured together so as to form one thick plate amalgamated practically throughout its whole mass. The object of this is to secure good amalgamation and to be able to use the cheap, impure zinc of commerce. These zinc plates are held in their porous cups, at and by their edges, by a three-sided grooved frame, the open side being at the top. The zincs are thereby held like a slate in its frame and may readily be replaced. This frame is made of copper, well amalgamated, and the contact between it and the plate is made by means of the mercury. This simple mode of supporting the zinc plates has many evident advantages; besides being readily replaceable, the zincs are completely immersed and consumed, and the contact is always good and clean. The liquid is dilute sulphuric acid.

Carbon plate.—The carbon plates are placed between the parallel portions of the porous cup as well as on the inside of the four sides of the jar, being mitered to hold them in place. The liquid is bichromate of soda.

Drain pipe.—There is a drain pipe connected with each cell, the object of which is to draw off automatically the old liquid at precisely the same rate at which the new liquid is being added, so as to keep the cell from overflowing or being drained. The liquid which has become passive is heaver than the fresh, active liquid and sinks to the bottom; the drain pipe must therefore lead it off at the bottom, while at the same time it must not allow the level of the liquid to change. To fulfill this condition it is made of two vertical concentric tubes, having an annular space between them; the inside one is open at the top at the normal height of the liquid and leads out through the bottom of the cell, and the outside one is open at the bottom and is higher than the normal level. The overflow, therefore, takes place from the bottom of the cell. There is one of these drains inside the porous cells and one outside. The supply of fresh liquid takes place in one corner of the cell and the drain is in the diagonally opposite corner, thus requiring the liquid to circulate continually through the winding parallel canals between the plates and the porous cup.

The liquids are supplied by lead tubes from two tanks above the battery. These tanks are filled by means of a very simple and ingenious, though not new, acid pump, consisting of a strong flexible rubber tube laid in the form of a semicircle and supported by a suitable guide; a wheel of slightly less diameter has rollers on its circumference, each of which in rolling over this tube compresses it

and thereby pushes the liquid forward, similarly to the mechanical action of the intestines of the human body.

Size and capacity.—A cell 18 inches square and 6 inches high, the active surface of the seven zinc plates being about 5½ square feet, gives about 2 volts on open circuit and 100 ampères on short circuit, showing an apparent internal resistance (including polarization) of 0.02 ohms. The normal rate of discharge is 30 to 40 ampères.

The Automatic Electrical Corporation, limited (English section, bronze medal), exhibited a complete combination primary and secondary battery for house lighting.

Details.—A comparatively small and compact primary battery is automatically and continually charging accumulators, from which the lights are supplied when required. The elements are amalgamated zinc in dilute sulphuric acid in a porous cup, and carbon in a solution of bichromate of soda. The fresh liquids are supplied by canals and the spent liquids are led off through holes in the bottom of the cells, closed by valves of special construction. The drainage and refilling are operated electrically, every twelve hours for the acid solution and every three hours for the bichromate solution. A clock starts this operation. The jars are of hard rubber; the reservoirs are of sheet iron, lined with lead.

Output and cost.—The battery exhibited is said to light ten to twelve lamps of 10-candle power six hours per day, allowing 25 per cent loss in the accumulators, and to cost $100. The zincs last about a week. The cost of running, per 1,000 watts (by which watt hours are probably meant), taken from a report of a reliable authority, is about 50 cents, divided as follows: Bichromate, 20 cents; sulphuric acid, 4 cents; zinc, 12 cents; mercury, 1.2 cents; labor, 11.5 cents. At the rate of 2 watts per candle this would correspond to 500 candle hours, or 0.1 cent per candle per hour, which, for a 10-candle lamp, makes one cent per hour. A company in London undertakes to install and run the battery, supplying everything, including the wiring for ten lamps, charging at the rate of 1 penny (2 cents) per hour per 10-candle lamp, which is certainly very cheap for incandescent lights from primary batteries. They use as a sort of meter the quantity of liquid used. In their factory they utilize the residues.

Renard cell.—Another battery of some importance, owing to the great power developed from small, light cells, is that of Commander Renard (French section), shown in the accompanying illustration (Fig. 30) and called the chlorochromic cell, or the tubular battery, on account of its appearance. It is at present used for small portable table lamps, the battery being in the base of the lamp, and it was suggested to be used to propel the great military balloon "La France." It is, no doubt, the lightest battery ever made.

General description.—The cell may be said to belong to the bichromate class, in which the bichromate of potash is replaced by

free chromic acid, and the sulphuric acid partially or entirely by hydrochloric acid. The cell consists of a long, narrow, cylindrical retaining cell of glass or ebonite. The negative electrode is a concentric tube, usually made of a very thin sheet of platinized silver; it may also be of carbon. The positive electrode is a long, thin rod of zinc, concentric with this silver tube and insulated therefrom. The general arrangement of a battery with twelve cells is shown in Fig. 30.

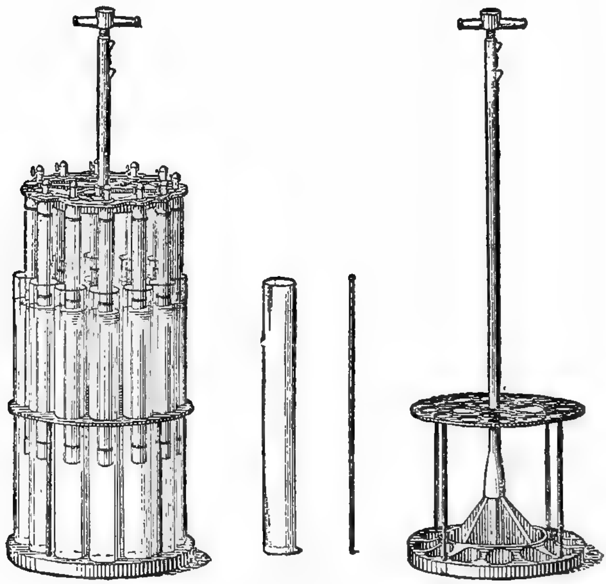


FIG. 30.—The Renard battery.

Solution.—A very thorough scientific and practical research seems to have been made to find the best proportions for the battery solution and to study its behavior. Of these results we give here only the most important conclusions. The tests are probably quite reliable. By replacing the usual sulphuric acid, part for part, by hydrochloric acid, it was found that the *rate of discharge* for the same cell was increased in proportion as the hydrochloric replaced the sulphuric, being increased fivefold when all the sulphuric acid was replaced, as compared with the usual bichromate solution with sulphuric acid alone. The *capacity* of all these new liquids, however, remains about the same; that is, as the rate of discharge increases the time of the discharge diminishes.

The more hydrochloric acid there is, the more tendency there will be to disengage free chlorine gas. The liquid should, therefore, not have too much hydrochloric acid and should not be prepared too long in advance. The mixture most frequently used for lighting, in which the proportion of sulphuric to hydrochloric acid (see below)

is 80 to 20, is quite stable and can be mixed two or three months in advance. When no sulphuric acid is used the instability of the liquid is so great that it ought not to be used longer than two days after mixing.

The following three liquids composing the mixture may be prepared in advance and kept in stock:

Liquid A: Chromic acid, 530 grams; water, 770 cubic centimeters.

Liquid BCl: Commercial hydrochloric acid of 18° Baumé (or a specific gravity of 1.143).

Liquid BS: Dilute sulphuric acid of 26° Baumé (or a specific gravity of 1.25), consisting of 450 grams acid of 66° Baumé and 800 cubic centimeters water.

The greater the proportion of the liquid BCl used, the more rapid will be the rate of discharges and the shorter the time of discharge. The capacity is the same for all, being 50 to 60 watt-hours per liter, the discharge being stopped when the difference of potential has fallen to 1.25 volts per cell. The following figures are deduced from a table given:

Properties.—Proportions by volume of the liquids A, BCl, and BS, respectively, 100, 20, and 80; specific gravity, 1.27; maximum current, 3.5 ampères; coulombs, stopping the discharge when the current has fallen to half its maximum value, 10,630; watt-hours, 3.54, and therefore the mean volts must have been 1.20, and the ampère hours, 2.95; watt-hours per liter of liquid, 54.6; watt-hours per kilogram of liquid, 43.0; weight of liquid per horse-power hour (metric), 17.2 kilograms or 38.2 pounds. For the proportions 100, 100, and 0 (*i. e.*. without sulphuric acid), the figures are very nearly the same, except that the maximum current is 8.5 ampères, the mean voltage remaining exactly the same.

Renard's improvement therefore exists in two things—namely, in replacing the potash or soda salt by chromic acid, and sulphuric by hydrochloric acid. One or the other of these changes alone will not have much effect, but it is with the two combined that the discharging rate is increased fivefold, and the total capacity increased 50 per cent.

Positive pole plate.—The positive pole plate is made of a sheet of silver, covered with platinum. It is 0.1 millimeter or 0.004 inch thick, the platinum coating being only about 0.0025 millimeter or 0.0001 inch thick. The platinum is necessary for protection, as the silver is attacked slowly when the platinum does not cover it. It is bent into the form of a long, narrow cylinder, the lap of which is left slightly open so as to allow the liquid on the outside to circulate and get into the interior to the zinc. The diameter of this tube should be about 0.4 to 0.6 that of the retaining cell. The cost of such an electrode 1 inch in diameter and 9 inches long is $1. Three little hard-rubber rings in the inside stiffen it and insulate it from the zinc rod, which

is passed through the holes in these rings. It may be replaced by a carbon cylinder, but platinized silver is preferred, as its conductivity is better and the weight and volume are less, the latter being practically nothing. It is very expensive, however, and should be replaced by carbon if the maximum output is not essential and the liquids not too concentrated.

Negative pole plate.—The zinc used is in the form of a thin zinc wire. It is made small in order to diminish the local action (which is proportional to the surface), and so that it may be consumed completely by one charge of the liquid. The smaller the surface of the zinc the more nearly is the consumption proportional to the current. Tests show that 1 liter of the liquid dissolves 85 grams of zinc. This would, however, require a zinc wire too small to be practicable, especially as the action is more rapid at the top than at the bottom, and would result in cutting it off at the top. It is therefore made slightly larger, in general 0.16 of the diameter of the cell, which is about one-fourth of an inch for the normal cell. It is not amalgamated for several reasons. It was found that after a certain point of concentration was reached, the amalgamated and unamalgamated zincs are attacked equally by local action. Furthermore, it increases the expense and makes such a thin rod as brittle as glass. Unamalgamated zinc also enables a leaden retaining tank to be used for table lamps, which would be destroyed by a single drop of mercury from the zincs.

Characteristics.—The characteristic of a cell is the curve obtained from the values of the difference of potential and of the current, corresponding to successive values of the external resistance varying from infinity (or open circuit) to zero (or short circuit). For a theoretically perfect cell, that is, without polarization, as, for instance, in a Daniell cell, this ought to be a straight line, as in the accompanying diagram, Fig. 31 (excepting the curved part KA), in which 1.67 would be the voltage on open circuit

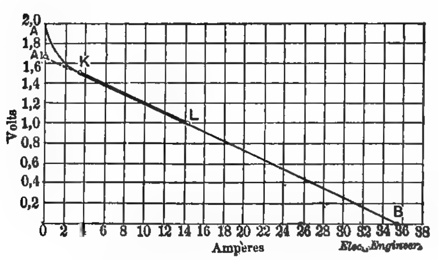


FIG. 31.—Renard cell; characteristic.

and 35.7 the ampères of current on closed circuit. The *constants* of such a cell would be the electro-motive force 1.67 and the internal resistance 0.047 ohms, which is evidently the quotient of 1.67 volts and 35.7 ampères. The characteristic shown is stated to have been obtained from one of these cells without sulphuric acid. The points K and L are those between which the cell is used in practice, for which, therefore, the constants are those given above. For other cells, however, this characteristic is always a curve. By drawing a straight line through that portion of such a curve which represents

the normal working conditions, and prolonging this line, the practical constants may be shown in the same way.

Output and capacity.—The following are some of the dimensions and capacities of these cells. Diameter of cell, 1⅝ inches; tube of silver, about three-quarters of an inch; zinc, about one-quarter of an inch; height, not given, but probably 9 to 10 inches; difference of potential while working normally, 1.20 to 1.25 volts; internal resistance, 0.17 ohm; discharge stopped when the voltage has fallen to about 1.12. The solution was the one described above, 100, 20, and 80. Twenty-four cells connected in series were discharged continuously through three lamps of 27 volts and 1.25 to 1.3 ampères each; the total quantity of liquid used was 6.3 liters; it ran 140 minutes, having given 347 watt hours, making 55 watt hours per liter of liquid, or 18 liters per kilowatt hour. Constructed as light as practicable, it will weigh 40 kilograms per kilowatt hour, everything included, or almost 66 pounds per useful horse-power hour. For practical batteries of this class, it is doubtful whether the weight can ever be brought materially below this figure.

The following are the dimensions and figures regarding the battery which is intended to propel the great military balloon "La France:" Cells, 4 centimeters diameter; silver tube, 3.2 millimeters; zinc, 6.4 millimeters. Total weight of a battery of twelve cells connected, six in multiple arc, 10 kilograms. The useful power at the end of one-half hour's running was 220 watts, thus requiring about four of these batteries per kilowatt; or with a motor, about four batteries, weighing 40 kilograms for a useful horse-power hour measured at the shaft. The weight that could be carried by the balloon was 400 kilograms, therefore making 10 horse-power, or 7.5 kilowatts for 1 hour and 36 minutes. While these results are very good and far superior to others obtained, the inventor himself admits that we can not hope that electrically driven balloons will ever be successful implements of war.

Table lamps.—The following data are given by the maker of a table incandescent lamp furnished with a battery of these cells in its base. Weight, complete, 35 pounds; height, clear, 33 inches; lamp, 25 candles; volts, 10 to 11; ampères, 4; mean duration, 5 hours; maximum, 8 hours; price, $60; cost of recharge, 50 cents; cost per candle hour, 0.56 cent. The liquid is raised or lowered by air pressure produced by a small rubber bulb.

References.—For a more complete description see the first volume of the Bibliothéque de la Revue de l'Aéronautique, a very complete abstract of which is published in l'Électricien, of Paris, Nos. 363, 364, March 29, 1890, from which the above illustrations were taken.

M. Gustave Trouvé (French section, gold medal) had an elaborate exhibit of primary batteries, chiefly for medical purposes and small lights and powers. They are almost all of the ordinary carbon,

zinc, and bichromate type, and leave little to be described. The small portable and pocket cells for medical and surgical purposes, and for small lights, are arranged in convenient form, as regards the plunging of the plates and prevention of spilling the acids. A small portable lamp battery has loose ribs around it like those of an umbrella, which ordinarily are not noticeable, but if the cells should start to fall over these ribs spread out and prevent it from falling.

He exhibited, also, a small boat run by an ordinary plunge battery. Apparently the only novelty is that the motor and propeller are on the rudder and are geared together by a chain gearing. For some additional remarks regarding this boat, see under "Applications of Power," p. 94.

M. Trouvé uses a more concentrated solution than usual; his proportions (by weight) are: 1 part bichromate of potash, 8 parts water, and 3.6 parts sulphuric acid. The constants of the cells for the boat are: 1.9 volts, 0.07 to 0.08 ohm internal resistance; four cells will develop 14 kilogrammeters per second for two hours running before it falls.

Modifications.—Most of the batteries exhibited using bichromate of potash for a depolarizer, have the zinc in a porus cup in diluted sulphuric acid. Among the principal modifications were the following:

M. Crosse (French section, honorable mention) replaces the usual carbon plate by a sort of cage of thin sheet lead, perforated and filled with fragments of retort carbon. The lead acts merely as a receptacle and a conductor for the carbon. The lead cage is made of two concentric cylinders united at the top and bottom, the annular space between them being filled with the carbon fragments. A lead terminal leads off the current. He claims as the advantages, that it is not fragile like carbon plates; it is cheaper; it offers great surface of carbon, lowering the resistance, diminishing the polarization, and thereby increasing the rate of discharge; it overcomes the objection to the unreliable brass terminal secured to the carbon plate. A 1-pint cell costing 50 cents is said to have a capacity of 30 ampère hours, at a rate of from 1 to 5 ampères. A 1-gallon cell costing $3 has a capacity of 250 to 300 ampère hours at a rate of 6 to 20 ampères.

Overflow tube.—The following simple and ingenious overflow tube was used in a number of different batteries of this class. The liquid in such cells, after it has performed its function, is heavier and sinks to the bottom. In adding new liquid to the old, the overflow of the old liquid should be from the bottom of the cell. This is effected by means of a vertical glass tube outside of the cell, the upper end of which tube is bent around in a semicircle, forming a nozzle for the liquid to flow out of. The lower end communicates with the inside of the cell through a hole in the bottom. The top curved part

of the tube must be just as high as the normal level of the liquid. When fresh liquid is added the old will, therefore, overflow automatically from the bottom. If this tube is connected to the cell by a flexible rubber tube, the cell can readily be emptied by bending down the tube.

Lagarde (French section, bronze medal) exhibited a battery for lighting purposes in which the carbons were revolved continually by an electric motor to agitate the liquid. The cells were arranged in a circle; the fresh liquid was supplied from a tank in and over the middle, the supply cock being opened electrically when the potential had fallen sufficiently. The zincs are perforated. The following data are given by the maker: Price of liquid, 4 cents per quart; 1 quart will run a 5-candle-power lamp for 1 hour. The price of the zinc, 40 cents; the set of twelve zincs will run 240 ampère hours; a battery of twelve cells gives 15 to 18 volts and 8 to 10 ampères, and costs $100.

In the battery of Mr. Pillet (French section), instead of raising and lowering the zincs the liquid is lowered and raised, respectively, by air pressure produced by a rubber bulb simultaneously on all the cells.

In the medical battery of Chardin (French section) this same principle is used to great advantage, making a clean, practically sealed cell, very well adapted for physicians and surgeons. The retaining cell is of porcelain, and consists of two parts. The upper one, containing the electrodes, is empty when not in use; the lower one is closed completely and contains the liquid. A tube communicates from the lower part of the upper to the lower part of the lower cell. By pumping air into the lower one, which is readily done by means of a rubber bulb, the liquid is forced up through this tube into the upper cell; by allowing this air to escape the upper cell is drained.

In the Bazin battery for lighting, the carbon plates are in the form of circular disks mounted on a common shaft which is revolved by a small electric motor; the revolving of the plates is claimed to diminish the polarization. In the curves of discharge exhibited, the difference of potential of 1 volt for currents of 9 to 10 ampères is shown to be remarkably constant for forty to fifty hours continuous discharge.

In the battery of Kornfeld (Russian section) the cells are very narrow, deep, rectangular boxes made of carbon plates cemented in some way at the edges, and heavily copper-plated on the outside. The box forms the positive pole; the zinc plate is lowered down into the box when in use, and is very close to the carbon on all sides, thus making the internal resistance very low. Liquid is supplied continually at the top, and is led out at the bottom in the usual way. The whole battery is very compact.

In the Chameroy (French section) battery the cell itself is a tube of carbon, the zinc being a concentric rod secured at the top and bottom. The liquid enters continually at the top and is led out at the bottom. The zinc rod is cast in the form of a screw with a very coarse, deep thread, whereby the liquid is made to circulate in passing down.

In the cell of Radiguet (French section, silver medal) the object is not only to lift the zinc out of its solution in the porous cup, when not in use, but also to empty this porous cup at the same time, to prevent diffusion of the liquids. To do this, there are two cups at right angles to each other, joined at their open end like the letter L inverted, and turning on a horizontal axis through this point, over one edge of the jar. One is porous and swings in and out of the jar, and the other is glazed and is outside. The zinc is placed in the porous one. To immerse the zinc its porous cup is turned vertically so as to be in the jar, and the liquid from the glazed cup flows into it. To withdraw the zinc, the two cups are rotated through a right angle, which empties one into the other.

In another cell of the same exhibitor, instead of using a zinc plate for the negative pole, he uses a copper tray or basket well amalgamated, filled with scraps of zinc and some mercury. The copper tray acts merely as a conductor, and is not attacked, if well amalgamated. The object is to use up scrap zinc.

In the Delaurier cell exhibited by Guérot (French section, honorable mention), designed chiefly for electro-plating, and consisting of zinc, carbon, and porous cup, the liquid used with the carbon is made of 87 parts ferro-chromic salt, 198 parts warm water, and 155 parts sulphuric acid. The liquid for the zinc is water, with a little of this added. The zinc need not be amalgamated. The chief advantage is cheapness.

Residues.—Among other exhibits properly belonging here was an interesting one of Mr. George Fournier (French section, bronze medal), which may prove of importance in cheapening bichromate batteries by finding a market for the residues of these cells. The exhibit comprised the various commercial products obtained from these residues.

His process of separating the residue into commercial products is briefly as follows: The residue coming from the batteries is a mixture of sulphate of chromium, sulphate of zinc, sulphate of potassium or sodium, sulphuric acid, chromic acid, and water.

The first process is to neutralize the free acid by means of scraps of metallic zinc. This is finished when the solution has become green instead of brown. During this process chrome alum crystallizes out, forming one of the commercial products, being used chiefly as a mordant. The oxide of chromium is then separated by precipitation at 212° F., by adding fragments of zinc or by oxide of zinc at

ordinary temperatures. This is finished when the solution has become quite clear. This oxide of chromium is the second commercial product. The remaining solution is treated with chalk, which precipitates zinc oxide, together with sulphate of calcium. This is finished when the liquid does not become turbid when ammonia is added. The remaining liquid contains only sulphate of potassium or sodium, or both, depending upon whether the bichromate of potassium or sodium was used in the battery. If only one of these was used this liquid, evaporated to dryness, forms the third commercial product. To the mixture of oxide of zinc and sulphate of calcium some sulphate of zinc is added until the solution is slightly acid, in order to be sure that no chalk remains; bichromate of potash is then added, forming a bright yellow precipitate of chromate of zinc, which is an excellent pigment and may be used for coloring paper, for paints, etc., having a great covering power, owing to the sulphate of calcium mixed with it. From the chromium oxides are then made different colors, mordants, chromic acid, metallic chromium, and it may be used in the iron and steel industries.

OTHER CELLS FOR LARGE OUTPUT.

Lalande & Chaperon.—One of the most interesting of the battery exhibits was the Lalande & Chaperon cell, exhibited by De Branville & Co. (French section, gold medal, for collective exhibit). It has gradually come into extended use, its numerous advantages giving it a very important place among batteries. It is a single fluid cell, with a solid depolarizing substance. It can be used for open circuits, for closed circuits, and for strong currents. The electrodes are amalgamated zinc and black oxide of copper; the liquid is caustic potash of 30 to 40 parts to the 100. The action is to dissolve the zinc and to reduce the copper oxide to metallic copper.

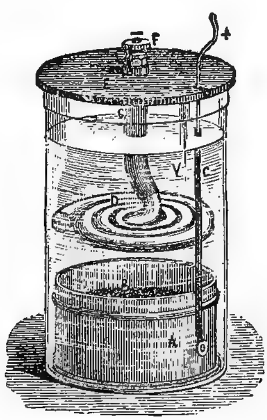


FIG. 32.—Lalande & Chaperon's cell.

Construction.—One of the principal forms, called the spiral form, is shown in the accompanying illustration, Fig. 32, in which D is the zinc spiral, and A is a thin sheet-iron box containing the copper oxide B and a copper-wire conductor, C, insulated where it passes near the zinc. The cell is 7¼ inches high and 4¼ inches in diameter. Another form, called the hermetic type, consists of a cast-iron bottle, forming the retaining cell and at the same time one pole, having the oxide of copper on the bottom. The zinc, suspended by an amalgamated brass rod, is held by the rubber stopper, which at the same time seals the cell. In the large hermetic type the zinc is

in the form of a large flat spiral, presenting great surface, and the cast-iron bottle is closed by means of three bolts and a rubber gasket. In the trough form, for heavy currents, the iron cell is in the form of a very shallow, flat, rectangular box. The layer of oxide of copper on the bottom is covered with a sheet of parchment paper, and the zinc is a flat sheet, with a brass lug attached to it. The liquid is covered with a layer of some thick oil. When a number of these cells are to be used in series, as for incandescent lights, they may conveniently be placed one over the other. The size and style of cell depend on the purpose for which it is to be used. The large trough form, about 16 by 8 by 4 inches, is designed chiefly for lighting, small powers, electrolysis, etc.

Constants.—The following constants of these cells may doubtless be relied upon as correct. The electromotive force on open circuit is from 0.8 to 0.9 volt. The following table gives some of the constants for continuous discharge, through an external resistance equal to the internal—that is, for maximum work—in which case, therefore, the difference of potential or useful electromotive force is slightly less than half of that on open circuit.

	Internal resistance.	Ampères.	Capacity in ampère hours.
Spiral form	0.15	1.5 to 2	70
Hermetic form:			
Small	0.15	0.5 to 0.7	15
Medium	0.10	1.5 to 2	70
Large	0.035	6 to 8	540
Trough form:			
Small	0.10	3 to 4	235
Large	0.35	6 to 8	540

See also the constants in the expert's reports given below.

Properties and uses.—There being no great polarization, the cells can be used on closed circuits without any stirring or circulation of the liquid; the difference of potential on closed circuit is said to fall slightly at first and then to remain nearly constant until the materials are almost consumed. The quantity of zinc consumed is very nearly that required by theory, showing that there is almost no local action and that it is therefore not necessary to raise the zinc out of the liquid when not in use. It is, therefore, well adapted for lighting on a small scale, for telegraphy, electrolysis, etc. The formation of the solution of zinc does not appear to lower its resistance, while the reduction of the oxide of copper to metallic copper diminishes the internal resistance. In using them for lighting or other purposes requiring much energy, they are used at or near the point of maximum output, which is when the external and internal resistances are about equal. But under these conditions the useful poten-

tial is also reduced to about a half—that is, to 0.4 to 0.5 volt per cell. Thus, for incandescent lighting it is necessary to have about twice as many cells as the pressure in volts at the lamps.

A battery of the large trough cells is said to run two lamps in derivation, presumably 12 to 15 volt lamps. A precaution is necessary in running lamps; as the initial electromotive force is about double the normal, it is necessary to switch a resistance in series with the lamps at the moment of starting, in order to save the lamps from the strain of the high initial electromotive force at starting. For charging accumulators, 4 cells must be used for one accumulator. For medical purposes it may be used for a surgical lamp or cautery. On account of its great current capacity it is especially well adapted for signal work or similar purposes, in which strong momentary currents are required.

As there is no local action consuming the zinc when not in use it is very well adapted for open circuit work, especially when the intermittent current required is comparatively great. It is largely used for microphones and for calls and has been adopted by the Société Générale des Téléphones at their central stations. Notwithstanding the low electromotive force, one cell is said to be able to replace a Leclanché, probably owing to its low resistance and the fact that it does not polarize. The latter property adapts it very well for telephonic transmission of operatic, theatrical, and musical entertainments, requiring long uninterrupted service. In such service one of these cells is replacing five Leclanchés.

The cell gives off no odors, forms no creeping salts as in the Leclanché, requires no adding of water or other attention. The solution of zinc formed is very soluble and no crystals attach themselves to the zinc, which therefore requires no cleaning or scraping. The attention and cleaning required by the ordinary Daniell cells used in the large telegraph central stations are by no means a small matter. In the main telegraph office in London, for instance, there are 27,000 Daniell cells, requiring three miles of shelving.

Regeneration.—After the oxide of copper has been reduced by the action of the cell it can be rendered active again by exposing it to the air for several weeks or by roasting it at a red heat on an iron plate. The cell can also be regenerated by passing a current through it in the opposite direction.

Capacity.—For the same weight the cell is said to have five times the capacity in ampère hours, as compared with accumulators. But such a comparison is misleading, as current can not be used without potential; as the useful difference of potential is between one-half and one-quarter of that of an accumulator, a true practical comparison should include both, in other words, should be a comparison of energy and not of ampère hours. For the same weight the useful energy may perhaps be one and one-half or even two times as great.

Precautions and objections.—The principal precautions to be taken are that the liquid does not come into free contact with the air, as that changes it into carbonate; and care must be taken not to get the liquid on the hands or clothes. The former is overcome by hermetically sealing the cells, or covering the liquid with a layer of oil. The latter objection is overcome by supplying the salt in an iron box from which it is poured directly into the cell, and water poured over it, so that no handling of the liquid is required. Another objection was that the zinc was rapidly eaten off just at the surface of the liquid. This has been overcome by fastening the zinc to an amalgamated brass rod or strip, so that the zinc is wholly immersed. There appears to be no local action if the brass is well amalgamated.

The prices are from $1 for the small one to $4 for the large trough cell. A recharge of zinc, oxide of copper, and potash costs about 80 cents for a small trough and about $1 for a large one.

These cells have been adopted by the Société Général des Téléphones, by the Administration des Postes et des Télégraphes, and are used among others in the London Post and Telegraph department.

Tests.—The following extracts are taken from various reports: M. E. Hospitalier discharged the small form illustrated above, Fig. 32, through 0.8 ohm, obtaining about half an ampère for 6 days' continuous running, or 259,000 coulombs (about 70 ampère hours). The theoretical capacity of the 88 grains of zinc consumed is 260,000 coulombs, showing an almost entire absence of local action. For full report see l'Électricien, August 1, 1883. Dr. d'Arsonval obtained 25 ampères from this one, and 106 from the large one, on short circuit. He found that by increasing the temperature from 20° C. (67° F.) to 50° C. (122° F.) the current increased from 4 to 12 ampères regularly with the temperature, and as the electromotive force remained the same this increase of current was due to diminution of the internal resistance. He also finds that there is no local action. See La Lumiére Électrique, August 25, 1883. In the Electrician (London) January 25, 1884, Sir William Thomson gives some results which he obtained. In La Nature, December 1, 1883, Hospitalier gives some results obtained with a small light.

CELLS OF THE LECLANCHÉ TYPE.

The chief exhibit of cells of this class was that of Leclanché & Co. (French section, gold medal), the original makers of the famous Leclanché cells.

Original cells.—These cells were usually made of a porous cup containing a plate of carbon and filled with broken fragments of carbon and native peroxide of manganese (the mineral pyrolusite of commerce); the negative pole is a zinc rod, and the liquid is chloride of

ammonia, the sal ammoniac of commerce. The zinc is amalgamated and the solution should be a saturated one.

Modification.—The improvement made some time ago, now already well known, and fast replacing the porous cup pattern, was to make hard, conglomerate blocks of the peroxide of manganese with the carbon, which blocks are held to the carbon plate by rubber bands; this replaced the porous cup and its loose contents. The resistance and polarization are thereby diminished, and consequently the useful difference of potential and current increased. These conglomerate masses are made of broken pieces of retort carbon, peroxide of manganese, and shellac, under hydraulic pressure.

Recent improvements.—The more recent improvements exhibited were the following: The conglomerate mass is made in the form of a hollow cylinder having a metallic terminal fastened to the top, as seen in the accompanying illustration, Fig. 33. The zinc rod, having a tinned wire terminal at the top, and a small rubber cap at the bottom is placed inside this cylinder and is held concentrically by the lid, as shown. This increases the depolarizing power of the peroxide of manganese, it being a more rational disposition of that material; the resistance is diminished still more, and the distribution of the current and consumption of the zinc is more symmetrical; the volume and weight are also diminished by this construction and the unreliable rubber bands are dispensed with. This construction enables the price to be diminished 25 per cent. The constants of this cell are: Electromotive force 1.5 volts, internal resistance (a few days after being set up) 0.4 ohm; weight of positive pole 1¼ pounds; price of cell complete 73 cents.

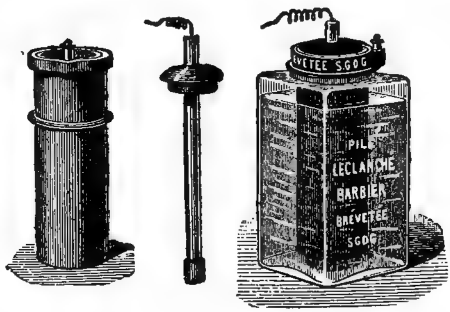


FIG. 33.—Improved Leclanché cell.

New salt.—Another one of their novelties is a new salt, to be used in place of the sal ammoniac. The latter has the very objectionable feature that crystals deposit on the zinc which thereby becomes insulated and is rendered inactive, and which causes the zinc rod to be eaten through or "cut off" at the top of the liquid long before it is consumed below. The positive pole also becomes clogged with these crystals. The new salt, which is said to be a mixture of 75 per cent of ammonium chloride and 25 per cent of chloride of zinc obviates the formation of these adhesive crystals and thereby keeps the zinc perfectly clean, enabling it to be consumed evenly and completely. It sells for 26 cents a pound.

Dry cell.—Another of their improvements for which they claim a great future is their so-called "dry cell," a poorly chosen name, as

the action of all such cells depends on their property of keeping *moist;* a better name would be humid or moist cells. It consists of a cylindrical vessel of zinc which forms the retaining cell and the negative pole; in this is a conglomerate cylinder similar to the one described above. Between the two is a mass of plaster of Paris, moistened with a solution of their new salt; the top is closed with wax. It is sold ready for use. It has the great advantage of requiring no setting up or cleaning, and is particularly applicable in cases where the cells are jolted about, as on trains, boats, etc. Its capacity appears to be almost the same as that of the usual cells (see Fig. 34). It sells for 87 cents.

The diagram, Fig. 34, gives a series of discharges of different cells, showing some of their qualities. The discharges were continuous, through an external resistance of 10 ohms.

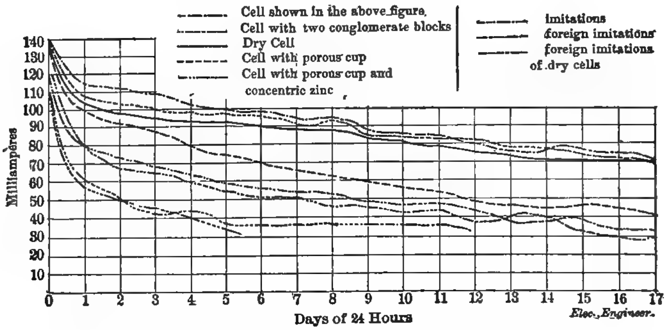


Fig. 34.—Curves showing the discharge of different Leclanché cells.

After thirty days' continuous discharge the dry cell still gave 50 milliampères; the discharge of the ordinary porous cup fell to this current in about fifteen days. The replaceable conglomerate blocks are of such a size that they are consumed in the same time that one zinc will last.

Minor improvements.—Some of the minor improvements are as follows: In the porous cup cells the porous cups have slits cut in them to increase their porosity. A "cavalry battery" to be used on horseback in military service is made of small carbon plates having a zinc plate cemented to it on one side with a paste of boiled oil and plumbago, making an electrical and mechanical contact; these are piled one over the other with sheets of blotting paper between them; the whole is strapped together without any retaining cell. To render it active the whole is dipped into the solution long enough to merely wet the blotters. All the cells are evidently connected in series by this construction.

Instructions.—The instructions regarding their cells are: that the zinc should be amalgamated and the solution completely saturated; that the new solution should be added when the old becomes milky;

that the addition of chloride of zinc solution is advantageous, and that tinned wire is preferable for connecting the cells.

Other exhibits of Leclanché cells.—Among the minor improvements of the Leclanché type of cells, as exhibited by different exhibitors, are the following: Henri Serrin (French section, honorable mention), exhibited retaining cells made of a single block of wood, lined on the inside with a waterproof coating. Two or more holes may be made in the same block, making a battery of cells complete in itself. He claims cheapness, strength, and lightness; being sealed there can be no creeping of the salts, and the cells are as convenient as the "dry cells." He claims that the blocks cost only 0.8 cent each to make. A complete battery of two cells in one block sells for 39 cents. He furthermore makes his contact on the carbon with a tinned zinc strip, so as to avoid the oxidation of the usual brass terminal.

J. Warnon (French section, bronze medal) exhibited a new form of terminal to the carbon plate. He claims that in the usual construction, local electrolytic action forms a salt between the metal terminal and the carbon, destroying the contact. In his terminal the brass binding post is tipped on its inside end with platinum, which presses against the carbon by forming the end of a screw which passes through the cast lead cap of the carbon. He replaces the porous cup by a coarse linen canvas bag soaked in turpentine and resin, inclosing the active material and tied around the carbon. He claims for this, cheapness and rapidity of discharge. For instance, a half-gallon cell with four carbons and selling for $1.16 gave 40 ampères on short circuit. He claims that he can regenerate the peroxide of manganese of old cells, so that it can be used over again. This is probably done by charging the cells in reverse direction. He also exhibits some small portable medical cells, 1 by 1 by 2½ inches, selling for only 19.3 cents each.

The Western Electric Company (United States section) exhibited Leclanché cells with the porous cups replaced by cotton bags; also porous cups with slots, and canvas around them; also porous cups with holes near the top to replace the usual glass tubes through the top; also glazed cells with numerous holes and a canvas bag on the inside, to replace the porous cups.

Ch. R. Goodwin (French section) makes a large cylinder of the conglomerate mass, having secured to it a zinc rod, forming together one piece. This he claims will give 2 to 2½ ampères on short circuit.

Messrs. Renault & Desvernay (French section, honorable mention) show a "dry cell" in which the moist mass is a siliceous gelatine.

OTHER CELLS FOR SMALL CURRENTS.

Among other cells for small currents not of the Leclanché type are the following:

Chas. Chardin (French section, silver medal), one of the principal makers of electro-medical apparatus, exhibited some very conveniently arranged medical cells, which he claims are almost half the weight for the same capacity, and which do not require the cleaning and attention of other cells, an important item for a physician. While the first cost is greater, the cost of maintenance is more than correspondingly cheaper. The cells consist of a high, narrow, cylindrical, retaining cell, having a carbon and a zinc rod fastened on the cover, which is common to all the cells of a battery. The liquid is bisulphate of mercury, filling about one-third of the cell; on this floats a large cork, which fits the retaining cell loosely. In the state of repose the electrodes are separated from the liquid by this floating cork, which also serves to almost seal the cell so as to prevent slopping. By depressing the electrodes this cork is forced down, and in doing so forces the liquid up to the electrodes, thus putting the battery into action. As it is necessary to raise the electrodes out of the liquid when not in use, the box containing all these cells is so arranged that the lid can not be closed until the electrodes have been raised, which is done by a counterweight or spring. The top of the box contains all the ordinary accessory apparatus used for medical purposes. The electro motive force is 1.526 volts.

The cell of Dr. Fontaine-Atgier, exhibited by Mors (French section), is also intended for medical purposes. The electrodes are zinc and copper, the latter having a mixture of peroxide of manganese and coke secured around it by means of a sack of thick, ordinary pasteboard. The liquid is potassium hydrate (the soapmaker's potash of commerce); the electromotive force is 1.49 volts. The advantages claimed are, that it can be used on open circuit work, it is quite constant and the resistance is low. A battery of a large number of cells is constructed without retaining cells, as follows: All the electrodes, as described above, are fastened in pairs connected in series, on a common lid, the zincs being tied against the pasteboard. To put it into action, the whole is dipped for a moment into a large tank containing the liquid, and is then withdrawn. Enough liquid is retained in the pasteboard to actuate the battery. The whole is arranged to be convenient for transportation.

L. Maiche (French section) exhibited a battery in which the depolarization is effected by the air. The negative electrode consists of scraps of zinc in a bath of mercury; the positive is made of a receptacle in the upper part of the jar, containing fragments of crushed coke which have been coated with a very thin layer of platinum black; this coke rests half in and half out of the liquid, allowing the air to be absorbed by the platinum black. It is claimed that one of these cells has been in action more than ten years without any attention. He also exhibited a salt to be used in place of sal ammoniac, which he says will dissolve eight times the quantity of zinc as compared with sal ammoniac.

CHEMICALLY PURE ZINC.

It is in place here to mention the exhibit of Louis Cahaigne (French section, bronze medal), who exhibited chemically pure zinc produced by a new process, by means of which it can be made cheaply. It is well known that local action in the zinc used in batteries is caused by the impurities in the zinc; if, therefore, the zinc is free from other metals it will not be attacked on open circuit, and will not need to be amalgamated, which is a source of trouble and entails no small expense. The process of this exhibitor enables him to make chemically pure zinc at a sufficiently low price to enable it to be employed in batteries. It can be made for 1 franc per kilogram, or 8.8 cents per pound, which is very low. Numerous reports from chemical experts were given, showing this metal to be really chemically pure.

Another process of obtaining pure zinc was exhibited by M. L. Letrange. This is an electrolytic process, but it belongs to the department of metallurgy and is, therefore, not included in this report.

MISCELLANEOUS.

Messrs. Perreur-Lloyd et Fils exhibited a battery in which the residue of the action was sulphate of copper. But as the electricity generated was a mere by-product, the object being to manufacture sulphate of copper, the description is given under the heading, "Electrochemistry," p. 154.

Mr. Thomas A. Edison exhibited a "chalk" battery, but as the action is probably thermic, it is described under that heading.

References.—For other generators of electricity, see respective headings. For battery carbons, see "Carbons," under "General Supplies." For substitution of dynamos for batteries on telegraph lines see "Telegraphy."

ACCUMULATORS.

GENERAL.

The lead accumulator as a practical commercial battery may be said to have originated about the time of the first electrical exhibition in Paris, in 1881, the chief inventors, Planté and Faure, being both from France. Although probably more capital has been spent in developing it, than in any other electrical appliance, its progress has been very slow and the results, even at the present time, are not what was expected or desired. They are, however, in sufficiently good form now to find considerable application in practice, which is growing very fast. But they still leave many points to be desired. They are at best heavy and expensive, and deteriorate rapidly; many of them, of the grid type, require considerable care, without which they will suffer greatly.

Development.—The development, as shown at this exhibition, is chiefly in the direction of details of construction and modifications intended to keep the active material from falling off and out of the supports. A number of developments have also been made in the Planté type, possibly because this form is not patented; these have been mainly in the direction of first preparing the material in the form of finely divided lead so as to be more readily formed electrically. Severally forms differing in their chemical action have been proposed, but as yet they are not any better than the lead cells.

Exhibits by countries.—The exhibits were principally in the French section, with a few from Switzerland, Belgium, Italy, and Austria.

Definition of terms.—Before describing the exhibits in detail it will be well to define some of the terms used, as there is great ambiguity respecting them, which unfortunately many manufacturers take advantage of to deceive purchasers and to make their goods appear much better than they really are. This has been carried to such a degree that statements of manufacturers have very little value. In giving the capacity of an accumulator, for instance, manufacturers often give the amount with which they are charged, which can evidently be increased very greatly by simply continuing the charge. It is the amount which they will yield on a single continuous *discharge* which is the important factor for determining the real capacity of a cell, and by which the number and size of the cells required for a plant must be calculated. This will here be termed the *effective capacity* and is the only one of importance. The true capacity should include the *mean effective difference of potential;* this is rarely higher than two volts, at a proper rate of discharge, and should never be less than 1.8 volts; a mean of 1.9 volts may therefore be taken as a constant, which, if anything, is too high. A discharge should be continuous and should be considered as ended when the difference of potential has fallen to 1.8 volts. The *capacity per pound of plates* is the effective capacity divided by the total weight of the plates complete; this weight should include all lugs and attachments to the plates which are a necessary part of them. The capacity of a cell depends also on the *rate of discharge*, which should therefore be stated; this, in order to compare different accumulators, is generally reduced to the *rate per pound of plates.* The usual rate is about half an ampère per pound of plates, but this is too slow a discharge for many cases, especially for traction purposes, in which the weight of the battery has to be carried by the locomotive mechanism. A good accumulator should stand a discharge of 1 ampère per pound without injury. A better way of stating the rate of discharge is to give the ratio of a discharging current to the capacity; for instance, if a 100-ampère hour cell is discharged at 20 ampères, the rate is 20÷100 or one-fifth; but this is evidently the reciprocal of the *time*

of the discharge in hours. This time is, therefore, an important factor; the shorter it is, for the same capacity, the better the cell, as the capacity diminishes rapidly with the time. A similar figure for the shortest time in which they can be charged is also of importance. The *efficiency* of a cell should really be the ratio of the *watt hours* instead of the *ampère hours;* the latter is the one usually given because it must necessarily be considerably higher, but it is the former which expresses the real efficiency of the storage of the power. The mean voltage of the charge and the discharge must be known to determine this, but it is seldom given; it may be assumed, however, that for any good accumulator the mean effective voltage of the discharge is 1.9 volts, and that of the charge is about 2.25, making an *efficiency of the volts* of about 85 per cent. If the efficiency in ampère hours, usually given, is multiplied by this efficiency in volts, the result will be the *true efficiency* of the energy stored, in watt hours. In all cases it should be stated whether a given efficiency is in ampère hours or in watt hours. The terms positive and negative plates will be used as defined by the electrical congress of 1889, namely: The positive plate is the one forming the positive pole of the cell, and is connected to the positive pole of the charging circuit; it is therefore the brown or peroxide plate. The negative is the other one.

Jury tests.—A number of the accumulators exhibited were tested at the Laboratoire Central d'Électricité for the jury. A few of the results obtained are given below in the detailed description. Although these results are correct, yet they were not all obtained under the most favorable conditions for the cells, and therefore should not be taken as the best results obtainable. The charging, for instance, was in all cases continued until the difference of potential reached 2.5 volts, which is too high, and consequently the efficiency is lower than it should be. On the other hand the capacity is for this reason greater than it would be ordinarily. The results obtained are not very good and are considerably lower than those given by the makers.

Mean capacity.—In general, for a good accumulator one can not count on much more than five effective ampère hours per pound of plates, which at 1.9 volts gives 9.5, or, say, 10 effective watt hours per pound of plates, which is equal to about 75 pounds of plates per effective horse-power hour, or 100 pounds per kilowatt hour. The proportion which the weight of the plates bears to the whole weight of the cell complete differs very widely in different systems, being in these tests between the limits 82 per cent for the Faure-Sellon-Volkmar and 44 per cent for the Dujardin. Assuming 75 per cent as a high average for a light cell, gives therefore about 100 pounds of cells complete per effective horse-power hour, or 133 pounds per effective kilowatt hour. These figures regarding the weights of the accumulators are of importance only when the cells are to be trans-

ported, as for traction purposes, car lighting, etc. If they are to be permanently installed in one place their weight is of little consequence. It is in all cases of interest, however, to the electrical engineer as it shows in a degree how effectively the materials are utilized.

Cost.—A poor practice has arisen in France (started, we believe, by the makers of a heavy accumulator) of selling accumulators by the pound. This is very irrational, as the better an accumulator is the lower would have to be its selling price for the same output in order to compete. Unless such a statement is combined with a guarantee of a certain capacity per pound it has no value, and, worse than that, it deceives the purchaser. The two statements might therefore just as well be combined at once, making a uniform system, which is rational—that is, to give the price per effective ampère hour. Such a system enables any electrician to calculate readily the cost of the cells for a certain output, and does justice to the better accumulator.

Comparative statement.—In order to be able to readily compare some of the common features of a number of the accumulators exhibited, the following table is prepared, giving a few practical deductions not usually contained in the published descriptions, and from which some fair, average, and useful figures may be taken. The results were all deduced directly, and only, from data published by the makers in their circulars. They are therefore quite fair for the makers, but not so for the purchasers, because some of the data as given have undoubtedly been exaggerated.

The first column contains the capacities, which are probably too high; the second, the capacity per pound, therefore also too high, the weight also being often underrated. It will be seen that from 4 to 4.5 may be assumed as a mean. The third, containing the rate of discharge, is probably nearly correct, but it is doubtful whether, at those rates, the capacities will be as stated, for the maximum rates have been taken in all cases. Half an ampère per pound may be taken as a fair mean. The greatest rapidities of discharge, in the fourth column, are probably close to the real values; a 5-hour discharge appears to be about the most rapid, the average being considerably slower. The fifth column has been deduced in order to endeavor to obtain an approximate idea of the average cost of accumulators, which has here been reduced to a common rational basis of cost per ampère hour. The prices used in this deduction are list prices, which are always subject to discounts, but at the same time there are generally a number of extras which tend to balance this discount, besides the fact that the capacities are generally considerably overrated, so that the figures here obtained, the quotient of the two, are probably not far from the true values. From 7 cents per ampère hour for the smaller ones to 4.5 cents for the largest may be taken as a rough mean. Of course these values will depend largely on whether the cells are for rapid or for slow discharge, also on the

nature of the retaining-cell and other factors, and are therefore no criterion, but they will answer very well as a general guide.

The classification is made according to the capacities, the sizes selected from the circulars being those corresponding most nearly to 100, 500, and 2,000 ampère hours. The data for the copper-zinc accumulator, whose eletromotive force is 0.75 volt, have been reduced to equivalent cells of 2 volts, in order that they may be compared directly with the others.

	Capacity in ampère hours.	Capacity per pound of plates.	Rate of discharge in ampères per pound of plates.	Rapidity of discharge in hours.	List price in cents per ampère hour.	Nature of cell.
Original Planté cell of 1860	17.15	7.25	....	....	....	
Huber	90	6.8	1.0	6.9	5.9	Glass.
Gadot	93.5	4.5	.87	5.2	6.6	
Faure-Sellon-Volkmar	100	4.5	.91	5.0	7.7	Ebonite.
Pollak	100	3.2	.63	5.0	8.7	Wood.
Garassino	100	6.0	.90	6.7	5.8	
Schoop	115	2.7	.48	5.8	6.5	Glass.
E. P. S.	120	....	....	3.0	9.3	Wood.
Elwell & Co. (copper-zinc)	200	39	4.9	8.0	3.1	
Elwell & Co., reduced to 2-volt cells.	200	13	....	8.0	9.3	
Cély (Sarcia)	250	4.5	.45	10.0	6.8	
Faure-Sellon-Volkmar	400	4.6	.69	6.7	4.3	Composition.
Pollak	400	3.2	.63	5.0	5.3	
Garassino	400	6.1	.91	6.7	3.9	
Gadot	475	3.2	.67	4.8	5.9	
E. P. S.	500	....	....	11.0	4.35	Glass.
Cély (Sarcia)	500	4.5	.45	10.0	5.8	
Schoop	500	2.5	.45	5.4	4.8	Glass.
Huber	565	7.1	.69	10.0	4.3	
Faure-Sellon-Volkmar	2,000	4.5	.68	6.7	3.9	Composition.
Cély (Sarcia)	2,000	4.5	.45	10.0	4.3	
Elwell & Co. (copper-zinc)	2,100	41.0	6.2	7.0	2.0	
Elwell & Co., reduced to 2-volt cells.	2,100	13.7	....	7.0	6.0	

Detailed description.—In the following detailed description the cells are divided into those belonging to the Planté type, the Faure type, and those belonging to neither.

CELLS OF THE PLANTÉ TYPE.

Planté's original accumulator.—In the personal exhibit of the late Gaston Planté (French section, grand prize) there were exhibited the plates of an accumulator of considerable historical interest, as they had constituted what was undoubtedly one of the first practical accumulators ever made. The plates shown were mere sheets of lead 19 inches long and 8 inches wide, one piece was light brown and the other gray. In the accumulator they had been rolled up together

spirally in the well-known Planté form. The following data accompanied it: "Made in 1860; unrolled in 1885; weight of both plates, 1.075 kilograms; one discharge deposited 20.425 grams of copper, which is equivalent to 61,765 coulombs." This capacity, reduced to more modern terms, is equivalent to 17.15 ampère hours, which therefore reduces to 15.95 ampère hours per kilogram of plates, or 7.25 per pound of plates. This result, obtained from the first accumulator thirty years ago, is even better than that obtained by many of the "improved" forms of the present day (see table above), including even the Faure type, in which the capacity is generally from 4 to 6 ampère hours per pound of plates, though more is often claimed by the inventors. This shows that as far as capacity per weight is concerned no progress has been made.

Dujardin.—The plates of the accumulator exhibited by P. J. R. Dujardin (French section, silver medal) are made of thin horizontal bands of rolled lead about three-eighths of an inch wide, having a roughened or ribbed surface, which are piled one over the other and connected together by a frame of lead cast around them, so as to form a plate three-eighths of an inch thick laminated transversely. In its form it is, therefore, very similar to the old well-known Kabath plates.

The chief novelty is in the process of forming the plates, which he claims can be done in 8 hours by a single charge, in place of the long, tedious formation in the usual Planté process. This he does by adding a certain salt to the sulphuric acid and using a very strong current for forming; this salt is used only in forming. It is a modification of the well-known process of hastening the formation by adding some nitric acid, the salt used having presumably the same function, namely, of assisting the more rapid oxidation of the lead. The objection to the nitric acid is that it is so hard to get rid of afterwards, for if any traces of it remain it will continue to oxidize the lead so that the whole frame is soon destroyed. Whether the particular salt used is more readily washed out of the plates after formation remains to be seen. If so, it is no doubt a valuable improvement over the ordinary process.

The negative plates are made of positives reduced by reversing the current. The plates being exceedingly porous, he is enabled to use fewer of them. In the cells shown there were one positive and two negative plates. The space between the plates is filled with a granular preparation of a burnt silicate which is exceedingly porous, resembling a sponge, and which renders contact between the plates practically impossible, but the internal resistance is probably increased considerably thereby. It is evident that an accumulator of this form will stand a very great amount of abuse without injury.

The following are some of the results of a test made for the jury: Weight of plates, 44 pounds; weight of cell complete, 90 pounds;

charge 375 ampère-hours, at 10 ampères; discharge 299 ampère hours, at 40 ampères. Deductions: 6.8 effective ampère hours per pound of plates; efficiency in ampère hours, 80 per cent; rate of discharge, 0.9 ampère per pound of plate; time of discharge, 7.5 hours. The charge was probably continued too long. In another smaller cell the results and deductions were as follows: Plates, 22 pounds; cell complete, 49.5 pounds; charge, 192.8 ampère hours at 20 ampères; discharge, 125.6 ampère hours at 20 ampères. Deductions: 6 ampère hours per pound of plates; efficiency in ampère hours, 62 per cent; rate of discharge, 0.9 amperes per pound of plates; time of discharge, 6.3 hours.

Pollak.—In the Pollak accumulators (Austrian section, silver medal) the spongy lead is formed on the plates themselves by a chemical method, as follows: The plate is covered with a paste made of a salt of lead (the chloride or the sulphate, we believe) which is then covered with a plate of zinc and immersed in acid. By a combined chemical and electrical action, the zinc is dissolved and the lead salt reduced to spongy lead, which is said to be very adherent. For positive plates these spongy lead plates are oxidized by the ordinary electrical process. The lead plates for holding this material are made in the form of a sheet with numerous minute teeth perpendicular to the plate; the material is held in place between these teeth which, when bent over slightly, after the active material has been put on, will form short hooks and will thereby tend to lock the material on to the plate. The reduction of the lead salt to spongy lead is said to require twenty to twenty-four hours. The chief claims for this accumulator are that it can be charged in six hours and discharged in five hours. This is undoubtedly a rapid rate, but it is permissible with almost any Planté accumulator. Strictly speaking, however, this belongs to the Faure type rather than to the Planté.

An ingenious modification, though not new, is the compound cell in which one retaining cell is divided off into several separate water-tight compartments by the plates themselves, which are secured to the box on their three edges by water-tight joints of soft rubber. One half of each plate is therefore negative and the other positive, each plate belonging to two neighboring cells. The object of such a compound cell is to increase the volts at the expense of the ampères, by combining several small cells in one receptacle. It is very necessary, of course, to guard against having any holes through the plates. This form is light, portable, and compact, and is especially well adapted for small lights.

Simmen.—In the Simmen accumulator (French section) the plates are made of fine hair-like threads of lead, made by pouring melted lead through a sieve and thence directly into water. This material is then compressed into plates, and a frame of lead cast around it. It is a question whether they will hold together after being thoroughly peroxidized.

Garassino.—In the Garassino accumulator (Italian section, bronze medal) the plates are made of a rolled sheet of lead having depressions and ribs, upon which is deposited, electrolytically, spongy lead; this is then compressed on to the plate forming a porous coating on the frame, which is readily oxidized for the positive plates by the usual Planté process.

Cély.—For the Cély cell, which might be classed among these, see below under the Faure type of cells.

CELLS OF THE FAURE TYPE.

Faure.—Philippart Frères (French section, silver medal) had the largest and most complete exhibition of accumulators. They are the makers under the Faure patents in France, and under the Volkmar patents for the grid, and the Sellon patents for the inoxidizable alloys of lead and antimony for the grids. They represent the Electric Power Storage Company in France. Their accumulator is too well-known to be described here. Their recent improvements are in the details of construction, the grid remaining the same as it has been. The present form of the plates is seen in Fig. 35. The

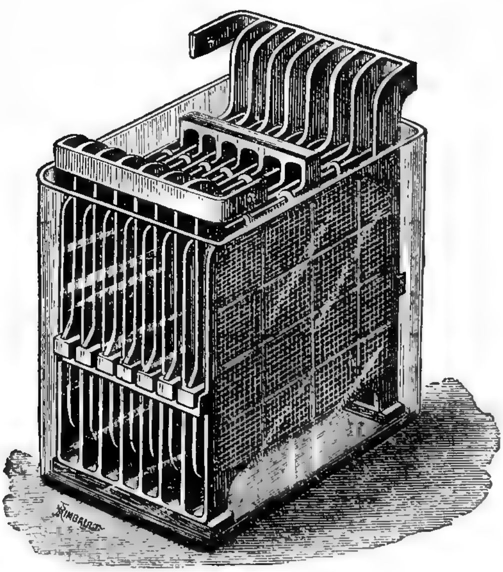


FIG. 35.—Accumulator; by Philippart Frères, France.

negatives alone rest on the bottom of the cell, while the positives are supported on insulating blocks resting on a shelf attached to the negatives. The positives may readily be lifted out by the sort of bridge piece in the center. The construction, though complicated, is quite practical, except that it does not permit the removal and

changing of a "sick" plate. Another improvement is their "twin" plate shown in Figs. 36 and 37, which explain themselves.

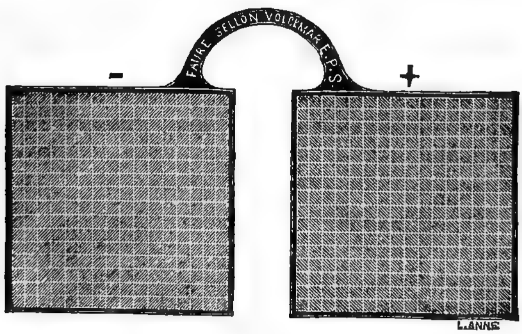


FIG. 36.—"Twin" accumulator plate.

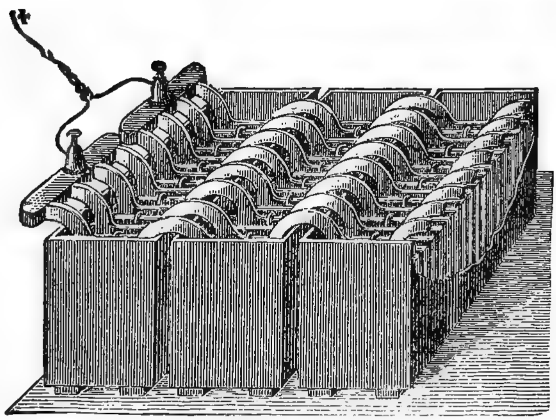


FIG. 37.—Phillippart Frères accumulator with "twin" plates.

This is a very ingenious contrivance for overcoming all soldered or other connections between cells, and furthermore enables any plate to be removed, examined, or changed, even while the cells are being charged or discharged. It has the slight disadvantage that there is no equalization of the capacities of all the like plates of a cell; they must therefore all be made of exactly the same capacity. This company appears to be selling large quantities of accumulators; they claim that, if properly taken care of, the plates will give no trouble. Their cells are used largely for house, as well as central station lighting, especially in England. They undertake to keep the cells in good order for from 15 to 30 per cent of the list price, per year. The test made for the jury gave the following results: Weight of plates, 26.8 pounds; weight of cell, complete, 32.7 pounds; charge, 137.9 ampère hours at 5.5 ampères; discharge, 108.5 ampère hours at 8.5 ampères. Deductions: Capacity, 4 ampère hours per pound of

plates; rate of discharge, 0.32 ampères per pound of plates; time of discharge, 13 hours; efficiency, 78.5 per cent. Notwithstanding the very low rate of discharge, the capacity per pound is not very good. At a high rate of discharge the capacity falls rapidly.

Historical.—Among their exhibits was one of the original Faure cells of 1881, consisting of sheets of lead having the active material held upon their surfaces by pieces of felt tied around them.

Julien.—Another large exhibit of accumulators of this kind was that of the Julien cell, exhibited by the Société Anonyme l'Électrique (Belgian section, gold medal). This accumulator differs from the Faure-Sellon-Volkmar only in details of construction; the general nature of the grid is the same. The plates are as a rule smaller, as are also the meshes of the grids. They claim as their point of superiority over the Faure-Sellon-Volkmar that their grid is not oxidizable and will therefore not only last longer but will not suffer as much from use. They claim to make their grids of an alloy of lead, antimony and mercury, which is said to be inoxidizable. While this may be so in a measure, it is not absolutely so, as the grids will corrode in time. The usual type of their cells differs little in appearance from the simple, well-known form. One prominent feature is that all connections in and about the cells are either soldered with homogeneous solder or are made by means of clamps of the same alloy, which is quite hard, not at all like lead. The following details may be of interest. The size of the usual plates is 7 inches square and one-eighth of an inch thick; distance between plates, about three-sixteenths of an inch; the meshes in the grids are one-fourth of an inch square; weight of a grid, 2.45 pounds; weight of a plate, 4.36 pounds; the weight of the active material is therefore about 44 per cent of the weight of the plates; in the bottoms of the glass jars are two inverted V-shaped ridges which support the plates clear from the bottom. The following are the results of the test made for the jury. Weight of cell, complete, 40.4 pounds; charge, 185 ampère hours at the rate of 12 ampères; discharge, 133 ampère hours at the rate of 34 ampères. Deductions: The weight of the plates was not given, but, assuming it to have been at the most 26 pounds, gives 5.1 ampère hours per pound of plates and rate of discharge of 1.3 ampères per pound of plates; time of discharge, 3.8 hours; efficiency in ampère hours, 72 per cent. It will be noticed that the rate of discharge is quite high, being more than one-quarter of the capacity, as the discharge was in less than four hours. The results are therefore quite good.

An interesting novelty exhibited by this same company was a battery of accumulators in which the plates themselves formed the retaining cells. The plates are made in the form of truncated cones closed at the small end; they have circular horizontal ribs on the outside surface and straight ones on the inside, perpendicular to the

others. They are coated on the outside and inside with the usual active material and are piled one above the other with the small ends down, so that each one forms a retaining cell into which the next one above is placed, leaving a thin layer of the liquid between the two; the inside of one cone forms the positive plate, and the outside of the one above, the negative plate of a cell; the cones are separated from one another by rubber rings. It is a cheap and simple form and will doubtless find considerable application for stationary purposes and small capacities and discharges. The only important objection is that if the upper edges of these conical cells become moistened with the spray, which is very likely to happen during charge, the cells will not hold their charge.

Gadot.—In the accumulators of Paul Gadot (French section, silver medal) the grid for the plates is made radically different from the usual type, as seen in Fig. 38, the first representing this new form and the second the usual form.

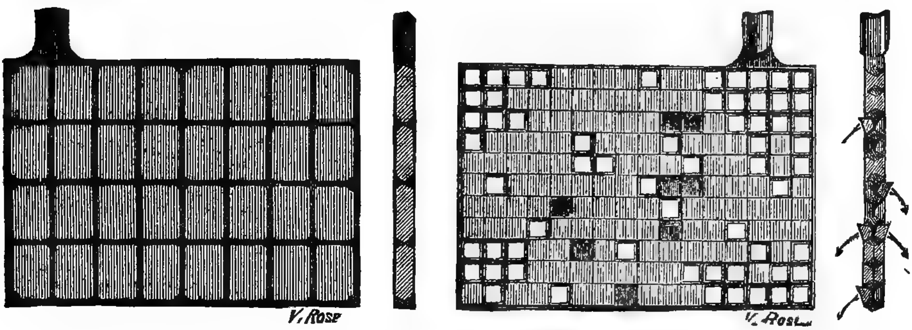


FIG. 38.—Grid for accumulator plates, by Paul Gadot; in comparison with a grid of the usual form.

It is well known that in the usual form of grids the holes or meshes are largest at the surfaces and become smaller toward the inside; the active material, therefore, having the shape something like a rivet, is thereby locked in the grid, but the force of expansion splits it through the middle and allows the two halves to drop out as shown in the figure. This is one of the chief faults of the ordinary form. To avoid this, Gadot makes the grid of two halves riveted together so that the flare of the meshes is toward the inside and not toward the outside; the active material is thereby locked in so that there is no tendency to split it, and it is almost impossible for it to fall out unless it is crushed almost to a powder. Another modification is that the meshes are made quite large, being 2 inches by ½ by ¼ inch thick. He thereby obtains much more weight of active material per pound of plates complete. He states that 48 per cent of the total weight of the plates is active material and 52 per cent is dead weight of frame. The resulting increase of capacity per pound is one of his chief claims. He gives as the normal rate of discharge 1 ampère per pound of plates, and as capacity

3.4 and 5 ampère hours per pound of plates, depending on the size. The formation is at the rate of about one-fourth of an ampère per pound, and lasts for 240 hours, including three discharges. The bar connecting all the plates of a cell consists of a horizontal bolt passing through the lug of each plate and through ferrules of lead alloy between the lugs, the whole being pressed together by nuts. This construction enables any one plate to be removed and replaced without any soldering. The results of one of the tests made for the jury were as follows: Weight of plates, 23 pounds; weight of cell, complete, 34 pounds; charge, 125.4 ampère hours at 10 ampères; discharge, 81.9 ampère hours at 10 ampères. Deductions: capacity, 3.6 ampère hours per pound; discharge, 0.44 ampères per pound; time of discharge, 8.2 hours; efficiency, 65 per cent. These accumulators are used largely in Paris for lighting purposes.

Cély.—Another accumulator of interest which is coming into use largely is that of Laurent Cély, sometimes known as the Sarcia accumulator, exhibited by the Société Anonyme pour le Travail Électrique des Métaux (French section, silver medal). It is sometimes classed under the Planté accumulators, but as the active material is made from compounds of lead, as distinguished from lead electrically oxidized, it belongs more properly to the Faure type. Their chief claim is that by their process of preparing the active material it is made extremely porous without losing its mechanical strength. The plates are made of a number of small, flat cakes of active material $1\frac{5}{8}$ by $1\frac{5}{8}$, by $\frac{3}{8}$ inch thick, having rounded edges. These are placed in a mold side by side, short distances apart, into which mold is then cast melted lead alloy, which fills the interstices between these cakes, binding them all together in the form of a large flat plate three-eighths of an inch thick, having the appearance of a large grid with very large meshes. The cakes having rounded edges, are, by this process of casting the frame around them, securely fastened in their frame. In the later forms these cakes are grooved on their surface with two straight grooves into which the molten metal flows, forming an additional means of holding them and increasing their contact with the lead. The cakes of active material are made by the following process: Chloride of lead is mixed with 15 to 25 per cent of chloride of zinc; this is melted, which requires about 900° F., the zinc assisting to make it more fusible; it is then cast in an iron mold into the flat cakes of the form required; these are then washed very thoroughly to dissolve any oxychlorides, as also the zinc chloride. The density of the lead chloride which remains is from 4.16 to 3.36, depending on the per cent of chloride of zinc used. In this form the frame is then cast around a number of them as described. The plates in this form are then connected to a sheet of zinc and immersed in water acidulated with hydrochloric acid. This reduces the chloride of lead to metallic lead, the zinc being dissolved. The

density of the lead cakes is then 3.09 to 2.50, and it appears to preserve the crystalline structure of the cast chloride. The density of metallic lead is 11.35, which is 3.7 to 4.5 times greater, showing the great porosity. These plates are then ready as negatives. For positives these lead plates may be oxidized by the Planté process, but they find that the peroxide is mechanically stronger if the oxidation is performed partially by chemical means. This process consists simply of heating the cakes (after reduction) in an oven in which they are converted into litharge. They are then peroxidized by the forming with a current, as usual. The peroxide obtained by this process is said to have a density of 3.57 to 2.88, that of ordinary peroxide being about 9. By density is probably meant the weight of the same volume, and is not the same as specific gravity. They claim to obtain 4.5 ampère hours per pound of plates, at a discharge rate of 0.45 ampère per pound. Their large plates are 16.5 inches square, three-eighths of an inch thick, and weigh 26½ pounds each; the large cells contain 10 negatives and 9 positives and weigh about 550 pounds, their discharging current being 250 ampères.

Huber.—In the Huber accumulator, exhibited by Cuenod Sautter & Co. (Swiss section), the plates are made in the ordinary grid form, as usual, with the additional feature that a small hole is pierced through the active material in the center of each mesh. The advantages claimed for this are that it is intended to allow for the expansion of the material, and thereby avoids all evils resulting from such expansion, such as buckling, falling out of the material, etc.; also, that it presents more surface to the action of the liquid, which enables the charging and discharging currents to be greater. Possibly, also, the active material is thereby more thoroughly utilized, giving therefore a greater capacity per pound of active material. The results of one of the tests for the jury were as follows: Weight of plates, 16.4 pounds; charge, 80 ampère hours, at 16 ampères; discharge, 64.6 ampère hours, at 10 ampères; deductions, capacity, 4 ampère hours per pound of plates; rate of discharge, 0.6 ampère per pound; time of discharge, 6.5 hours; efficiency, in ampère hours, 81 per cent.

Schoop.—In the Schoop accumulators, exhibited by the Oerlikon Company (Swiss section), the chief modification is that the whole jar and the space between the plates is filled with a mineral jelly or gelatine, called a "solid electrolyte," made by mixing soluble glass with sulphuric acid. The intention is to have it act as a porous partition between the plates, to prevent their touching by buckling or falling out of the material. It is hardly probable, however, that this soft material would not be pushed aside by the great force exerted when a plate buckles. Another improvement is, that in the large positive plates the current is led off from all four corners, and from the center of the negative plates, the intention being to avoid

buckling by a more even current distribution over the plates. It is very probable that the gelatine used increases materially the internal resistance and diminishes the rate of charge and discharge.

Pollak.—For the Pollak cell, which might be classed among these, see under Planté type of cells.

OTHER TYPES OF CELLS.

Reynier.—The only other accumulators of importance exhibited and not belonging to either the Planté or Faure types were the Reynier and the copper-zinc accumulators. The Reynier is well known, consisting of zinc as a negative and peroxide as the positive plate. It has the advantage of a higher voltage, it being from 2.3 to 2.5 volts. It has such grave faults, however, that it appears to have been abandoned, and was exhibited only as a voltametric regulator, to be used in connection with a dynamo, to regulate the potential and to act as a reserve device in case of accidental stoppage of the dynamo.

Cadmium.—Another exhibitor used cadmium and tin, in place of zinc, but without apparently any great gain.

Copper-zinc.—The other accumulator, of a radically different type, is one exhibited by Elwell & Co. in the French war department, and used in the French navy. It consists of porous sheets of copper as positive plates and sheets of amalgamated tinned iron as negatives, the liquid being a concentrated solution of zincate of potash. On charging, the copper absorbs oxygen and is changed into yellow suboxide of copper; the zinc is deposited on the tinned iron; the potash is set free. They require no forming, and are said to stand any rate of charge or discharge. A set of fifty of the smaller cells was used in an experiment on a street car, and is stated to have given 45 ampères and 35 volts, making 1,575 watts for 3¼ hours, and is said to weigh 700 pounds. This would make about 100 pounds of cells per effective horse-power hour. As a good lead accumulator of the ordinary type will weigh about 110 to 120 pounds per effective horse-power hour, and even less, this new form is not much lighter than the well known forms. Their chief disadvantage is their small voltage, which is only .75 volt, or about one-third that of the lead accumulator. To be equally light for the same power it must give about three times the capacity in ampère hours per pound of plates, and even then there will be three times the number of retaining cells. It is reported, furthermore, that they do not retain their charge well and that the liquid tends to change into carbonate when in contact with the air.

This form of accumulator, slightly modified, has lately been introduced into this country, under the name of the Waddell-Entz accumulator; it is also closely allied to the Lalande & Chapron or the Edison-Lalande primary battery.

V.—ELECTRICAL MEASURING INSTRUMENTS AND SCIENTIFIC APPARATUS.

GENERAL.

The exhibits of the higher class of electrical measuring instruments, though confined to those of but few exhibitors, were the products of the very best makers of the world, and may therefore be considered as representative of the latest and finest apparatus of this class. There were also a number of exhibitors, who, though not ranking among the highest, had excellent exhibits of apparatus of certain classes, and specialties, such as apparatus for research, instruction, and demonstration, commercial instruments, Geissler & Crooks tubes, etc. In general, the exhibition of electrical instruments was very good and complete, representing the principal manfacturers of the world and the latest and best products.

Progress.—The progress shown was chiefly in the direction of improvements in the class of testing and measuring apparatus, the improvements being mainly to facilitate the using of such apparatus, rather than to develop new forms, though some important progress has been made in the latter direction also.

Among the more important improvements are the Deprez-d'Arsonval galvanometer, the change of the divisions in resistance boxes, the newer forms of electrometers and electrometer voltmeters, the Lippmann instruments, the Thomson ampère balance, the Wimshurst influence machine, and, in the direction of apparatus for research, that of Elihu Thomson.

Exhibits by countries.—The exhibits were confined almost entirely to France, England, and a few from the United States. Those of France were by far the largest in numbers, and, with the exception of Elliott Brothers, the most important also. In the English section there were, besides Elliott Brothers, who, with Carpentier, are the first in the world, a few very creditable exhibits. Those from the United States were limited to the apparatus for research of Elihu Thomson and Edison.

Awards.—The importance of the various exhibits may be judged from the principal awards given in this field by the jury. J. Carpentier of Paris, and Elliott Brothers of London, both received the very high award of grand prizes. Latimer Clark, Muirhead & Co. (Great Britain), and Richard Frères (Paris) received gold medals. Dalloz, Gillet et Guyot-Sionnet, Gaiffe et Fils, and Patterson & Cooper received silver medals. Besides these, Breguet was "hors concours," being represented on the jury, and Ducretet was classed in the section of instruments of precision in which he received a grand prize.

Classification.—In the accompanying detailed description, the exhibits are described in the following order: galvanometers, electrodynamometers, electrometers, resistance boxes, ampère and volt meters, meters, and miscellaneous apparatus. As most of the apparatus is already well known in a general way, no attempt is made here to give a thorough description, a familiarity with the well-known apparatus being assumed. The description is confined merely to a summary of such points as are of interest because of their novelty or of their importance, or of their recent development. Apparatus for demonstration and instruction has not been included, as it has undergone little recent development.

GALVANOMETERS.

Elements.—To facilitate the description of galvanometers they may be considered as consisting in general of three essential elements, namely: first, the part through which the current to be measured passes, usually in the form of a coil of many turns of wire, with the object of multiplying or magnifying the effect, which it does in proportion to the number of turns in the coil; second, a light movable part which is moved by and in proportion to the magnetic force exerted by the current in the coil; third, a directing force which gives the movable part direction and antagonizes the force exerted by the current, so that the resultant of the two will indicate the measure of the current. In the ordinary well-known galvanometers the coil is fixed and must be placed with its axis east and west; the movable part is a small light magnet suspended on a fiber without torsion, or on a pivot, and the directing force is the magnetism of the earth which tends to hold the magnet north and south.

Definition of terms: Constant.—The following are the principal terms used in connection with galvanometers to indicate their properties, such as the currents for which they are to be used, etc. The "*figure of merit*" of a galvanometer indicates what is usually referred to as its sensitiveness; that is, it is a constant which indicates how small a current can be measured with the galvanometer; it therefore gives a number by which different galvanometers may be compared with each other in this respect, provided the same unit of deflection has been used. The *figure of merit* is defined as the reciprocal of the current which will produce one unit deflection on the scale. A high figure of merit therefore shows that the galvanometer will measure very small currents; that is, it is very sensitive. For this the French use the better term "*constant*" of a galvanometer, which is defined as the resistance, usually in megohms, through which one volt will produce one unit deflection. It may readily be

shown that the two terms are absolutely the same; that is, that the *figure of merit* really is this resistance which is called the *constant.* The two terms may therefore be used interchangeably. This constant is readily obtained for any galvanometer in which the deflections are practically proportional, as follows: Connect a battery to the galvanometer through a resistance, and read the deflection, usually in millimeters; divide the total resistance by the electromotive force and multiply by the deflection; the result is the required constant or figure of merit in ohms; if galvanometer shunts have been used, the correction must be made. In a large tangent galvanometer the constant is usually that current which deflects it 45 degrees; this is the reciprocal of the other constant; the unit of deflection, however, is different, so that no comparison can be made, except with other tangent galvanometers.

Aperiodic.—Aperiodic is synonymous with the term *dead beat* and means that the movable part of a galvanometer comes to rest quickly without oscillating to and fro a number of times, be it when it is deflected or when it returns to zero. In a certain class of galvanometers which are aperiodic only when the circuit is closed, the *limit of aperiodicity* is the greatest resistance in the external circuit with which they will be aperiodic when returning to zero; that is, when the pointer will not pass by the zero on returning to rest.

Ballistic.—A *ballistic* galvanometer is one in which the moving part has considerable inertia; it is used for measuring momentary currents, the principle being that the moving part does not begin to move until the momentary current has ceased; the deflection is then a mere single oscillation. Strictly speaking it measures coulombs, and not ampères.

Astatic.—An *astatic* galvanometer is one in which the directing force of the earth's magnetism is made exceedingly small by having two needles connected on the same spindle, and turned in opposite directions, so that only the difference of their directing force acts while the current acts on their sum, thereby increasing the relative power of the current.

Exhibits.—The objects of improvements exhibited are, variously, to increase the constants or figure or merit; to increase the aperiodicity; to make them independent of the magnetic field of the earth, dynamos, moving iron masses, etc.; to make them less delicate to handle, and to simplify and cheapen their construction.

Thomson's galvanometer.—The well-known Thomson single-coil and double-coil astatic galvanometers were exhibited by Elliott Brothers, of London, their original makers, who do not appear to have modified them any; they are too well known to require description here.

Carpentier's modification.—Carpentier exhibited a modification, the object of which is t› make all the parts readily accessible, and

also to enable the coils to be changed, all of which is done with merely a few thumb screws.

Fig. 39 shows the galvanometer complete. The plate glass faces can be pulled out from the top; by unscrewing the two thumb screws B B, the front plate, shown in Fig. 40, containing the front halves of the two coils, can be removed, leaving the needle spindle, with the mirror, damper, and suspension exposed, as seen in Fig. 41, allowing any adjusting and repairing to be made. The bolts and

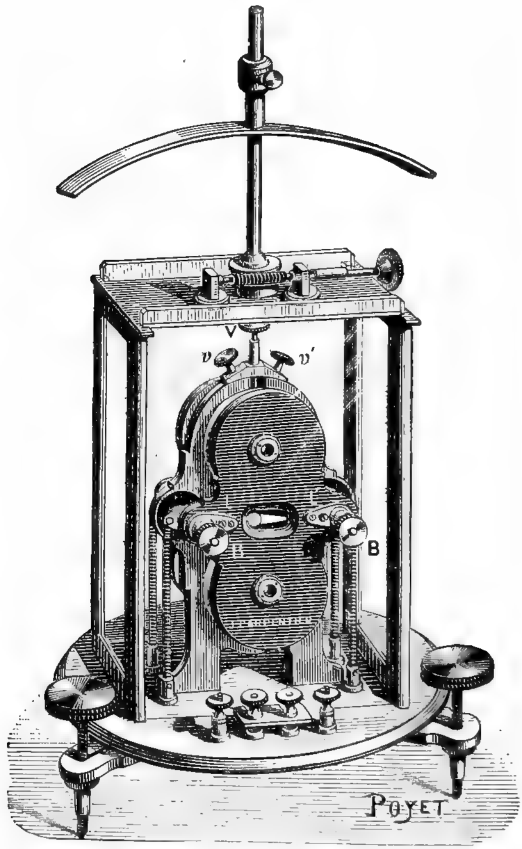


FIG. 39.—Modified Thomson galvanometer; by Carpentier, France.

nuts BB' are so arranged and insulated with ivory that the act of screwing on the plate (Fig. 40) makes all the connections required. The rear plate may be removed similarly, and both may be replaced by other coils of a different resistance. The little lozenge-shaped air damper also prevents the spindle from making a complete revolution. The form is a very practical one, and is an important improvement on the original form. The following are some of the dimensions and constants of the most sensitive one made: Coils,

60,300 turns of wire one-tenth of a millimeter diameter, about No. 38 American gauge; resistance, 16,130 ohms. The constants vary according to the position of the directing magnet on the top. The time of an oscillation in coming to rest will increase with the constant, but not in as rapid proportion. For constants of 800, 1,600, and 15,000 megohms per millimeter deflection, the time of a single oscillation was 4¼, 7, and 21 seconds, respectively. Distance of scale, 1.1 meter.

CARPENTIER'S THOMSON GALVANOMETER.

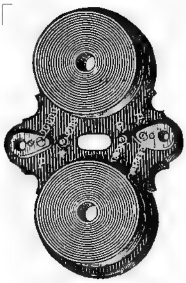


FIG. 40.—Front plate, carrying halves of the coils.

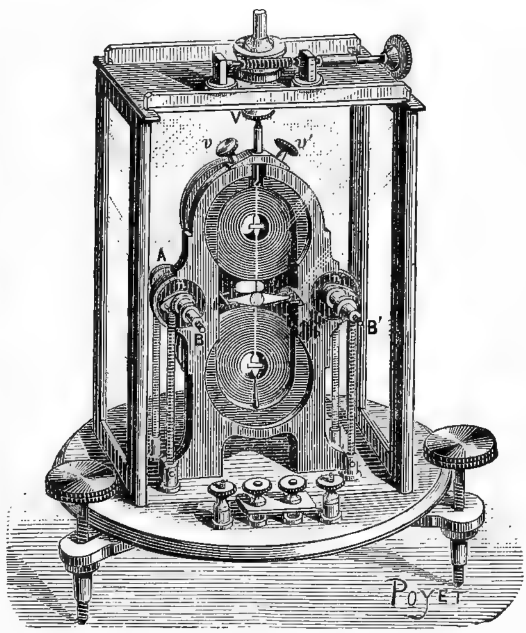


FIG. 41.—The galvanometer with the front plate removed.

Deprez-d'Arsonval.—The most important and interesting exhibit of galvanometers was unquestionably that of the so-called Deprez-d'Arsonval galvanometer, made and exhibited by Carpentier, of Paris. This instrument is so simple and eminently practical, and has such excellent qualities that it will doubtless replace most of the other forms of galvanometers, besides creating new uses in places where the older forms could not be used on account of their being affected by so many surrounding conditions. It is already in use very largely in France, and it would doubtless meet with the same favor in the United States. The principle is essentially the same as that used in the well-known Weston instruments.

Principle.—The galvanometer consists, as shown in Fig. 42, of a U-shaped magnet, having a small cylindrical piece of soft iron be-

tween its poles, secured by means of a standard in the rear. The small, light coil of wire is wound around a small, open, rectangular frame, and is suspended as shown so that it can revolve freely around the suspension as an axis, the two long sides of the coil moving in the most intense parts of the field. The suspension wires are the leads to and from the coil. The current to be measured passes through the coil and tends to revolve it, precisely as if it were the armature of a small motor. The suspension wires are soldered at their ends, and their torsion acts to give the coil direction and to antagonize the force exerted by the current; the upper one can be

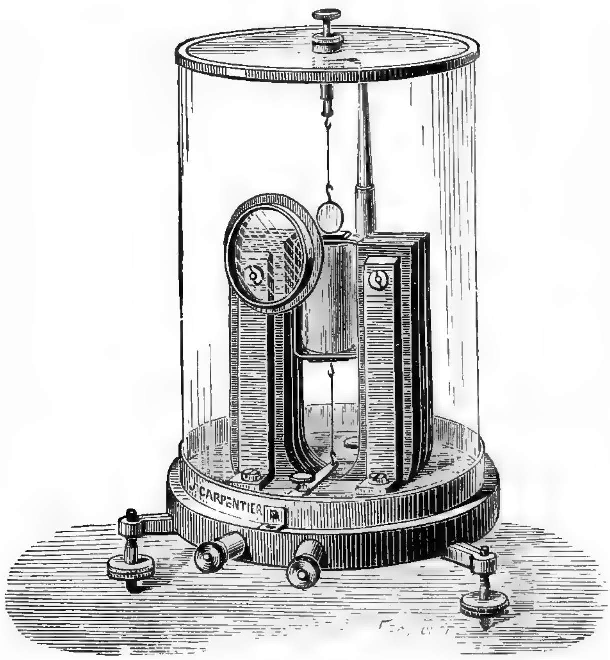


FIG. 42.—Deprez-d'Arsonval galvanometer.

twisted slightly to set the coil to zero. The order of things in the ordinary galvanometer is, therefore, reversed; instead of having a large, fixed coil and a small, light, movable magnet, the coil is here made light and movable, while the magnet is large and fixed, the weak and variable earth's magnetic force being replaced by the reliable and invariable torsional force of a wire. In any galvanometer, the deflecting force is proportional to the product of the magnetism of the coil and the magnet; in the old form of galvanometers, the former is great and the latter is necessarily small; in the present form it is just the reverse, the magnets being made very powerful.

Historical.—The idea of this disposition is not new, it having been suggested by Maxwell and used by Sir William Thomson in his syphon recorder, but we believe that it was not until 1880 that it was applied to commercial galvanometers by Dr. d'Arsonval. The same principle is applied, at present, in a more compact form here in the United States in the Weston commercial volt meters and ampèremeters.

Properties and advantages.—Among the chief advantages, besides simplicity, are that it is aperiodic or deadbeat, and that it is independent of the earth's magnetism or that of surrounding bodies. The field produced by the magnets is so intense that the earth's magnetism is practically nothing compared to it, and even the presence of dynamos and other magnets or moving masses of iron have practically no effect on the deflections.

The aperiodicity is due to the fact that the movement of the coil when deflected generates a counter electromotive force which tends to reduce the original, the result being that the pointer or spot of light will move slower and slower as it approaches its point of rest, and will not pass it and oscillate. In the same way it will come to rest at its zero, provided that the galvanometer is short-circuited so as to allow the current, which is generated by the moving coil, to flow, and thereby to oppose the motion. This aperiodicity is not only a great saving of time, but enables the galvanometer to be used when instantaneous readings must be taken, and when, therefore, the ordinary galvanometers can not be used.

The sensitiveness or figure of merit increases with the magnetism of the magnets, with the number of windings on the coil, and with the length of the suspension wires; it diminishes as the suspension wire is larger. For the same coil and magnets the figure of merit may be varied by merely changing the size of the suspension wires. It can be used with shunts, as any ordinary galvanometer. If used with a spot of light and ordinary scale, the deflections are proportional to the current. The zero point depends only on the suspension wires and therefore remains fixed if they remain unchanged. The same figure of merit or constant can be obtained with a much less resistance of wire than in the ordinary galvanometers, being equivalent therefore to a low-resistance galvanometer with a high figure of merit or constant.

Even the most sensitive forms, however, do not equal the figure of merit of the double astatic Thomson galvanometer.

Constants.—In the form used most frequently, shown in the above figure, the coil has about 200 ohms resistance, the suspension wires are of silver, fifteen one-hundredths of a millimeter, or about 0.006 inch (No. 34) diameter, and each about 2 inches long; the constants vary from one to four megohms, and the limit of aperiodicity is about 500 to 600 ohms, that is, when short-circuited through this

resistance (or anything less), it will not pass by the zero in moving back after having been deflected. The transparent scale is usually half a meter long, graduated in millimeters, and is placed at a distance of one meter. The tenths of a millimeter can readily be estimated, and correspond to a deflection of the coil of 10 seconds or one three hundred and sixtieth of a degree.

Modifications; ballistic—There were exhibited many modifications in details for special purposes. Fig. 43 shows the form used for a ballistic galvanometer. The coil is made very large and with its greatest dimension perpendicular to its axis, to increase its inertia. The two U-shaped magnets, with their like poles together as shown, form the outside of the galvanometer. The coil is 50 by 64 millimeters and is composed of 500 turns of one-tenth of a millimeter wire, having a resistance of 500 ohms. The suspension is by means of silver wires of one-tenth of a millimeter and 70 millimeters in length. The constant is 100 megohms. It gives forty-three divisions for a discharge of a micro-coulomb. Its limit of aperiodicity is about 6,000 ohms, which is exceedingly high. When allowed to oscillate freely its period of oscillation is about 6 seconds, while when short-circuited it requires 4 minutes to return to zero, the aperiodicity is so great; by properly timing the moment of this short circuit, this time can evidently be reduced to a few seconds only; this overcomes the objections to ordinary ballistic galvanometers, in which the needle requires a long time to come to rest. It is claimed that it will measure correctly momentary currents, even if their duration is several seconds, as in the case of large dynamo field magnets.

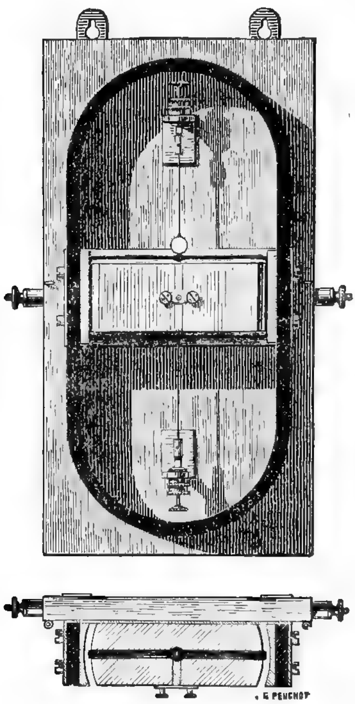


Fig. 43.—Ballistic galvanometer.

Proportional direct reading.—To obtain a direct reading galvanometer with proportional readings, used chiefly for medical purposes, and graduated in milliampères, a modification of Figure 42 is used. One pole of the magnet is connected directly to the cylindrical iron core, which, in this case, is hollow; the other is connected to an open cylinder of iron encircling this first pole, leaving an annular space between them, which forms the single field. The rectangular coil is suspended so as to turn on one of its sides as an axis, and not in the field, while the other moves in this annular field. The deflec-

tions are through an angle of 180°, and are sufficiently proportional, varying only 2 per cent. They are made to correspond to milliampères by an adjustable shunt coil. For an illustration and description see La Lumière Électrique, May 11, 1889, p. 270.

Sensitive form.—If the coil is held at top and bottom by two thin and long wires it is too apt to tremble. To obviate this the coil is for such purposes suspended by a single long thin wire from the top only, while the other connection is made by a platinum wire at the bottom dipping into a mercury cup; the mercury is covered with a solution of cyanide of potassium to dissolve the film of oxide formed whose viscosity would affect the free motion of the platinum wire. The constant of this is 125 megohms per millimeter deflection; even this however does not compare with the best Thomson, whose constants are as high as 15,000 to 16,000 megohms per millimeter. When zero methods alone are used the magnets may be electromagnets and the field thereby increased considerably, increasing the figure of merit.

Other modifications.—It is made also in the form of a differential galvanometer, the coil being wound double, and the suspension being bifilar both at top and bottom. The difficulty in any differential galvanometer is to have the action of the two coils absolutely the same, so that if the same current be passed through both, in series but in opposite directions, there should be no deflection; the difference found in one of these was only one seven-hundredth, which is exceedingly small. For absolute proportionality to the current in any of these galvanometers the upper suspension is so arranged that it can be turned so as to bring the coil back to zero for every deflection. The angles of torsion are then absolutely proportional. When it is desired to have several spools of a different number of turns and different constants for the same galvanometer they are arranged with each one on its own standard, so that all that is necessary is to change the whole standard, which requires but a moment, the connections being made by the act of fastening the standard. The sensitiveness may also be changed by raising, more or less, the whole standard with its coil, thereby bringing less of the coil into the field. In a form used for measuring heat, the coil itself is a single, short-circuited, thermal couple suspended on a cocoon fiber. The heat to be measured is radiated upon one junction, the other being covered by the mirror. The couple is held in direction by a small piece of iron wire fastened to it.

Claude form.—The above were all made and exhibited by Carpentier. A few other makers also exhibited this form, among which was one exhibited by F. A. Claude (French section) as a relay for a particular system of telegraphy in which the relay must operate for widely differing currents. The single magnet was flat; the coil was a flat ring, in the plane of the magnet and revolving on its diameter,

which was perpendicular to the lines of force. A fixed, flat, circular disk of iron inside of the coil increased the intensity of the field; the whole formed a very compact and simple apparatus.

Deprez galvanometer.—Another very simple and convenient galvanometer also exhibited by Carpentier was that known as the Deprez or the "fish bone" galvanometer. It consists of a magnet, as seen in Fig. 44, a fixed coil in the same plane with it, and a small flat piece of soft iron pivoted so as to turn on its axis inside of the coil and between the magnets. This iron is usually cut on its outer edges, resembling somewhat the backbone of a fish, from which its name. When a current passes through the coil the field produced, being perpendicular to that of the magnets, changes the direction of

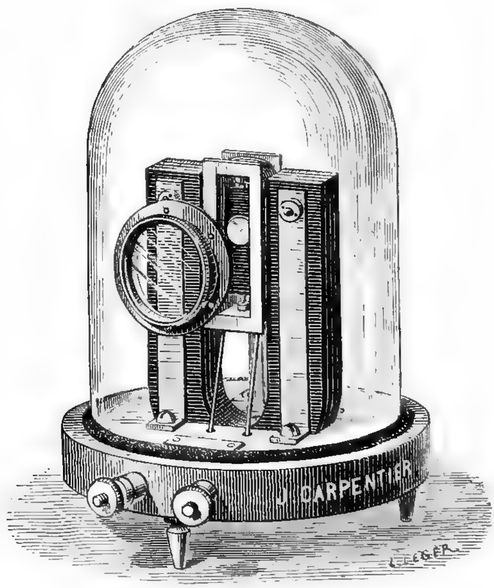


Fig. 44.—Deprez's galvanometer.

the resultant lines of force, and thereby deflects the iron piece. Its advantages are that it is portable and exceedingly simple; the deflecting forces are comparatively great, its action being therefore quick and decided. The deflections are, however, not at all proportional. It is particularly applicable when a decided and definite deflection is required, as, for instance, in a maximum and minimum volt indicator exhibited, in which a pointer attached to the iron piece moved between two platinum contact points quite close together, so that if the deflection changes one or the other of these contacts would be closed, ringing an alarm. The deflection is opposed by an adjustable torsional spring, by which it can be set to the required number of volts. Its accuracy is said to be within 1 per cent. Another form

of this galvanometer exhibited is used by the municipal authorities in Paris to test the leakage from the incandescent mains. It is portable and conveniently arranged in a closed box, with a small reading telescope having the scale in the inside.

Wiedemann galvanometer.—Branville exhibited a galvanometer of the Wiedemann type, devised by d'Arsonval, the most important novelty of which is that the needle with its mirror, copper damper, and suspension are all in one tubular piece, which can be readily removed and the needle or suspension examined without any alteration in the adjustments of the galvanometer.

Heat galvanometer.—Edison exhibited a deadbeat galvanometer similar in principle to the well-known Cardew voltmeter, and which it is claimed antedates the latter, having been invented in 1880. It consists of a long fine platinum-iridium wire, one end of which is secured and the other is wound around a small shaft, which therefore rotates as the wire expands and contracts by the heat of the current passed through the wire. A spiral spring opposes the pull of the wire, and a mirror on the shaft indicates the deflections by means of a spot of light; the whole is inclosed in a glass tube through which the terminals are fused and from which the air has been exhausted.

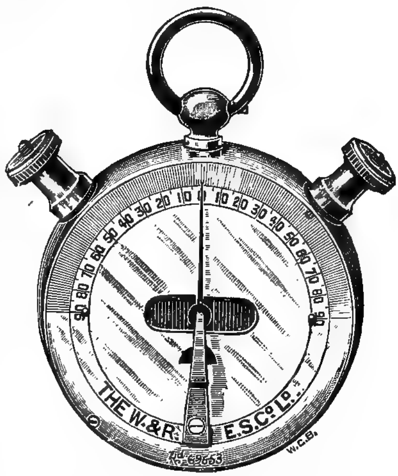


Fig. 45.—Pocket galvanometer.

Pocket galvanometer.—Messrs. Woodhouse & Rawson (French section) exhibited a very convenient form of pocket galvanometer having the external appearance of a watch, as shown in Fig. 45, which explains itself. The needle is balanced and pivoted with two pivots, and the field is doubtless an artificial one of a permanent magnet.

Accessories; scale.—Among the accessories appertaining to galvanometers were a few exhibited by Carpentier, which are of interest.

The scale almost universally used with all his reflecting galvanometers, shown in Fig. 46, is of translucent celluloid, supported on an extension stand with a weighted base. It is always graduated in millimeters, and is usually 50 centimeters long, with the zero at one end, instead of in the middle as usual with the English Thomson instruments. This single-scale system enables readings to be taken over the whole length of the scale, and also enables all deflections to the right or left to be taken without setting to zero every time, the subtraction necessary in this case being often less troublesome than setting for zero in a double scale. If the same deflection is to be taken

to both right and left, to get their mean, it is less troublesome, because in that case no zero reading need be taken at all. This system

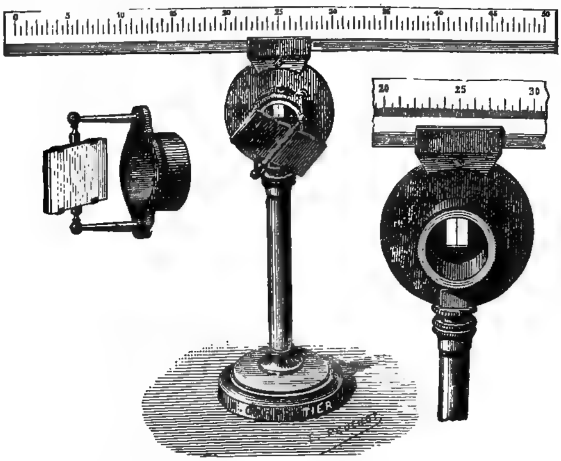


Fig. 46.—Celluloid galvanometer scale.

of single scale seems to be used almost exclusively in both France and Germany in place of the double scale or central zero scale used

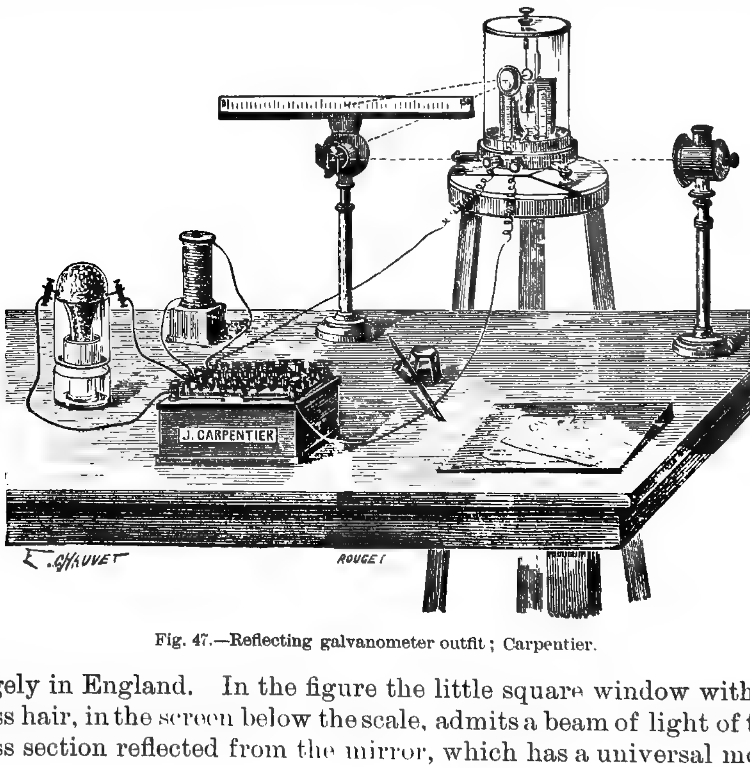


Fig. 47.—Reflecting galvanometer outfit; Carpentier.

largely in England. In the figure the little square window with its cross hair, in the screen below the scale, admits a beam of light of that cross section reflected from the mirror, which has a universal move-

ment; this beam of light is seen on the scale in the form of a large, bright, square, spot, and can therefore be found or followed quite readily. The sharp, black line through the center enables the reading to be taken with precision. A lamp light, and even a dark room, though preferable, are not necessary, as the light from a window, reflected by the mirror, is sufficiently bright to enable the spot of light to be seen even if the room is not darkened. The complete galvanometer outfit in its simplicity is seen in Fig. 47. As a source of light, the spring candlestick shown, with a flame fixed in position and surrounded by a proper reflector, is an excellent substitute for the objectionable lamp. The brass plate under the galvanometer, with three radial grooves, enables the galvanometer to be insulated and cushioned with rubber, while its position is determined by the grooves, so that it can always be put back into exactly the same position after having been removed.

In the Mudford modification of the scale exhibited by Patterson and Cooper, in the British section, the cross wire is placed between the condensing lens and the galvanometer, so as not to be magnified by this lens. This is claimed to give a much sharper and finer image of this line on the scale than if the wire were placed on the other side of the lens.

Novel desk outfit.—A somewhat novel disposition was shown, but we fail to see its advantage except to save space and to protect the galvanometer. The galvanometer is placed in the bottom of the table or desk, the beam of light being reflected upward by means of a reflecting prism. The scale lies flat on the desk over the galvanometer, and a long, narrow mirror at an angle of 45° over it makes it appear to be upright, so that it is seen just as usual.

Portable outfit.—In another form, a very convenient and compact portable outfit, the galvanometer is in a box through one side of which a small reading telescope is introduced close to the mirror, having a microscopic scale of 120 divisions in the inside near the eyepiece, which is magnified so as to be almost as large as a millimeter scale. An adjustable window, with a cross hair on the neighboring side of the box, and a small adjustable reflector of white paper, illuminates the whole field of the telescope and shows a black line, which can be sharply focused by the telescope.

ELECTRO-DYNAMOMETERS.

General.—Electro-dynamometers, which measure the relative force between two currents, have lately come into use largely in meters for measuring and registering the quantity of electric energy supplied to a purchaser. The electro-dynamometer is used in these meters in order to take into account both the volts and the ampères delivered, by indicating or measuring their product—that is, the watts, for which reason they are often, and correctly, called "watt

meters." For a description of those used in meters, see under the heading "Meters."

Thomson balances.—The Thomson electric balances, which are also electro-dynamometers, were not exhibited, but they will be mentioned under the heading "Ampère meters."

For telephone currents.—The French Telephone Company exhibited a small electro-dynamometer for measuring the very small currents in a telephone. It consisted of two small, vertical, circular coils of three-fourths of an inch diameter, one was fixed and the other was movable, being attached to the end of a small horizontal lever of 1½ inches length, which was suspended by a single cocoon fiber so as to turn about this as an axis. Contacts to and from it were made by wires dipping into mercury. The torsional force of the fiber opposed the repelling force of the two coils and thereby indicated the strength of the current.

ELECTROMETERS.

General.—Electrometers appear to be coming into use gradually, in practice, as distinguished from scientific research. Their undoubted superiority in certain special cases is being appreciated more and more, as, for instance, for alternating potentials, for very high potentials, or for measuring potentials without causing a current to flow. The direction of improvement has therefore been to construct them in as practical form as possible, rather than to try to improve the general principle of their action, which latter has remained absolutely the same as Thomson's original suggestion, namely, the lateral attraction of two electrified plates to a third one, moving between them and electrified oppositely. They are already used in a very simple form as commercial voltmeters for high potentials above 500 volts, such as in arc-light circuits.

Carpentier's form.—One of the most important improvements shown was in the form exhibited by Carpentier. The directing and deflecting forces in an electrometer being necessarily very small, the needle in the usual forms will oscillate very slowly and for a long time, which is very objectionable and often prohibits the use of the instrument. The object of the present construction is to overcome this and to make it aperiodic. This is done by developing an intense magnetic field in the space through which the movable part oscillates. This develops Foucault currents in the moving parts, which oppose and check its movement without in the slightest way affecting the deflection. The form of the instrument is seen in Fig. 48, and resembles somewhat in external appearance the Deprez-d'Arsonval galvanometer described above (Fig. 42). The electrified quadrants of the electrometer are made in the form of a cylinder, split longitudinally into four parts, a form adopted a number of years ago by Edelmann, of Munich. A similar split cylinder is in the inside and

concentric with it. The movable part is in the form of a light rectangular metallic frame, like a shallow box without top or bottom, and is usually made of aluminum. It is suspended by torsion wires, as seen, so that it can revolve, its long slides moving through the annular space between the quadrants. The quadrants and movable frame are electrified, as usual, either by the potential which is to be measured or by means of a high potential battery in addition. In the former the deflections are proportional to the square of the potential; in the latter they are simply proportional to the potential. The torsion of the suspension is the opposing force; the magnets are merely for making the movement aperiodic, and have no other function; they therefore do not affect the constant. The most delicate form is said to give a deflection of 3 millimeters for 1 volt with a 100-volt charging battery, and 25 centimeters for 70 volts without a charging battery. The same form, except that the cylinder is horizontal and the counterforce gravity, is made in the form of a volt-meter, which see under that heading. These are made up to 3,000 volts.

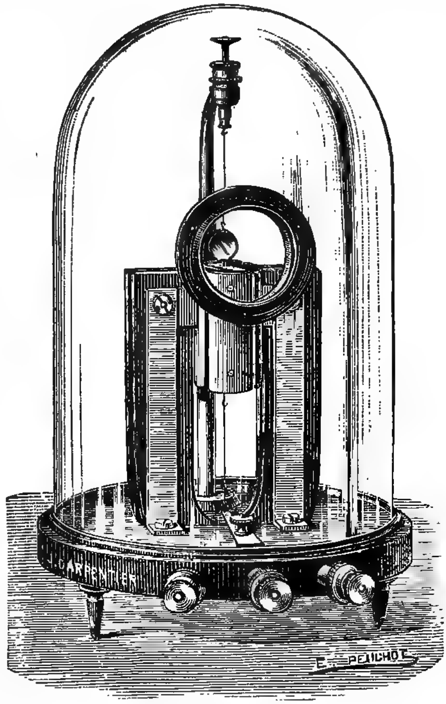


FIG. 48.—Carpenteir's quadrant electrometer.

Mascart's form.—Another electrometer, exhibited by Carpentier, was one devised by Mascart. It is in general like the well-known Thomson quadrant electrometer, but is modified in details of construction so as to bring it into a more practical form. It is principally for laboratory purposes, and is used chiefly for measuring atmospheric electrification.

Blondlot & Curie form.—Another form of some interest is that devised by Messrs. Blondlot & Curie, and exhibited by Ducretet (French section). It is somewhat like the Thomson form, except that it has only two sets of "quadrants," instead of four, in this case in the form of two semicircles. The "figure-8" needle is replaced by a round, light disk of aluminum, also cut into two semicircles, and moving between the upper and lower plates of the semicircles. These fixed semicircles are magnets, so as to act at the same time as

dampers, to make the motion aperiodic. The central moving plate is suspended by long torsion wires, one-fiftieth millimeter in diameter, as in the Carpentier form, acting also as leads. It may be used with or without a charging battery. In the former case the two halves of the moving part are connected to the charging battery and the others to the unknown potential; in the latter case the semicircles are connected in pairs. For further description, see La Lumière Électrique, October 23, 1886.

Lippmann capillary form.—Bréguet and Ducretet both exhibited the Lippmann capillary electrometer, which appears to be coming into use gradually. It is limited in its application, but is a very good instrument in its field; that is, to measure potentials less than one volt down to one ten-thousandths of a volt. Its principle is that the surface of contact between mercury and acidulated water in a capillary tube will change its place in the tube when the two liquids are electrified. Readings are made with a microscope. It is prompt and aperiodic, and is said to be used in anatomical researches to measure the variation of electrification accompanying muscular contractions. It is used in electrical laboratories for standardizing by certain methods in which only very small differences between two potential measurements are to be detected or measured. For a further description, see Traité d'électricité, Vol. 2, by Mascart.

Voltmeters.—For electrometers which are arranged as commercial voltmeters, see under that heading.

RESISTANCE BOXES.

General.—Resistance boxes were exhibited by many makers, but the finest were unquestionably those of Elliott Brothers, of London, and of Carpentier, of Paris. With the exception of the improvements noted below, there was little to be described. Legal ohms are adopted universally by French makers, while English makers still use the B. A. unit largely, though all Elliott coils are made for either. German-silver wire is still used almost entirely for the French coils, while the Elliott coils are made largely of platinum silver alloy, which has a lower temperature coefficient.

Division of coils.—One of the principal modifications which appears to be coming into use and replacing the older form is shown in the Elliott box, Fig. 49.

The coils are arranged in groups, each of ten equal coils, one group of units, one of tens, etc. This very greatly facilitates plugging and avoids errors in readings; it has the additional feature that the number of plug contacts (four in this box), and therefore their resistance, is always the same, which is not the case in the old form, in which the number varies with every resistance unplugged. On the other hand, it increases both the size and the price of the box, as there must necessarily be two and a half times as many coils (as

ten is to four) for the same range of resistance. In another box of Elliott, Fig. 50, the adjusting is even more convenient and rapid, by means of the levers and sliding contacts shown.

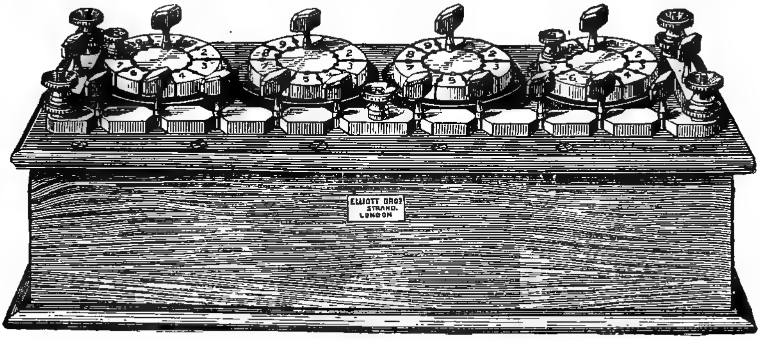


FIG. 49.—Resistance box with plugs; Elliott Bros.

These contacts are so arranged that they make contact with the next coil before they leave the previous one, so as not to open the

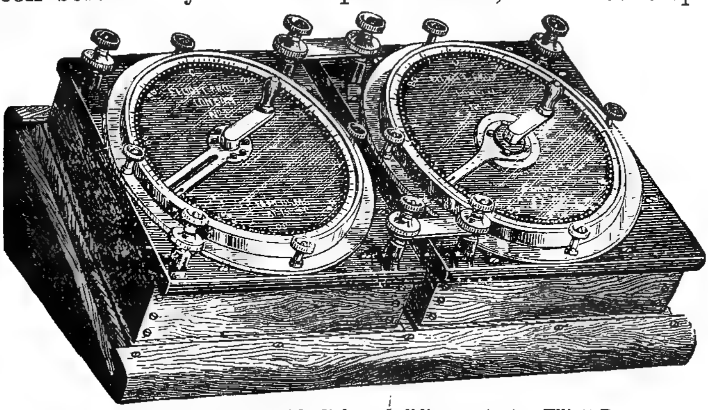


FIG. 50.—Resistance box with dials and sliding contacts; Elliott Bros.

circuit; one revolution on one box corresponds to one step on the next. Bréguet exhibited one similar to this, with the additional

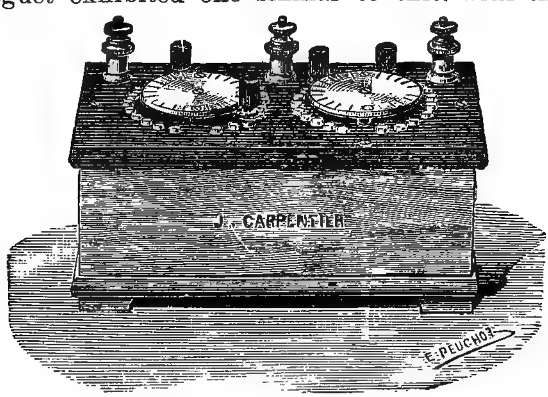


FIG. 51.—Carpentier's dial resistance box.

feature that every complete revolution of the right-hand lever will move the left-hand one forward one step. In the Carpentier box, Fig. 51, the same arrangement as in Fig. 50, is modified so as to have four groups, namely, units, tens, hundreds, and thousands, of ten each, arranged in four semicircles, and with four levers; this is not quite as convenient, but is much more compact, as there are only

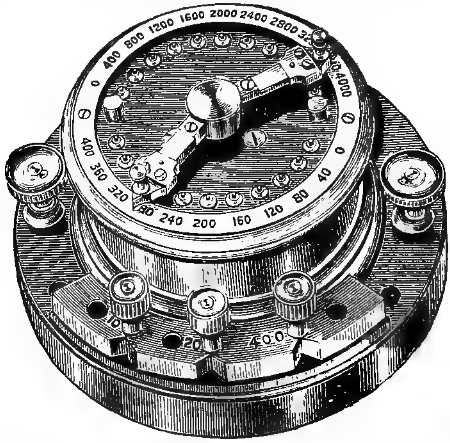


FIG. 52.—Compact form of resistance box; Elliott Bros.

forty coils, while in the other, Fig. 50, there are two hundred for the same range and degree of adjustment. All these are less reliable and accurate for very exact work.

A somewhat similar but much more compact form, made by Elliott, is shown in Fig. 52, and is used exclusively for telegraph work, chiefly for balancing a duplex system. Edison exhibited one for a

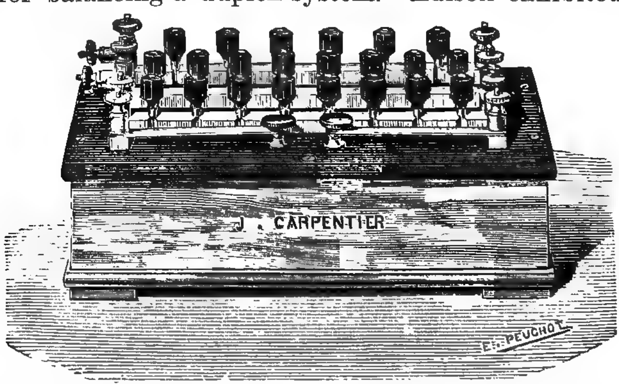


FIG. 53.—Carpentier's resistance box with plugs.

similar purpose consisting of disks of silk, saturated with a sizing mixed with plumbago, which after being dried are placed over one another forming a pile which is compressed by a screw with a divided head.

Plug heads of the form shown in Fig. 53 have replaced the old lozenge form altogether in the Carpentier boxes. They are much more

convenient, and do not break like the old form, which is very weak in the middle; they have the additional advantage that in plugging, in a compact box, one is not so apt to loosen the neighboring plugs by accidental pressure from the fingers. Another improvement noticed was that the boxes were sometimes accompanied by plugs fitted with a binding screw at the top, to enable a wire to be connected to any special one of the coils.

Legal ohms.—Carpentier (who is the maker of the French national standard ohm) exhibited standard ohms in various forms, including mercury ohms in glass tubes. In connection with standard ohms he exhibited also a large, massive Wheatstone bridge for comparison of standard ohms.

Artificial lines.—Latimer Clark, Muirhead & Co. exhibited their combined resistance coils and condensers, the object of which is to make adjustable artificial lines, having both capacity and resistance combined in proportion to their length. They are made of strips of tin foil which are so proportioned in size and so wound that they have both capacity and resistance in the same ratio as the lines with which they are to be used. The transatlantic cables are duplexed with these artificial lines.

AMPÈREMETERS AND VOLTMETERS.

The number of different systems of ampèremeters and voltmeters exhibited was about as great as the number of electric lighting companies and instrument makers combined; each one had his own system. Most of them appeared to be sufficiently good as ordinary commercial apparatus, the purpose for which they were intended, but few deserved to be ranked among reliable and accurate measuring instruments. The underlying principle of most of them was the electro-magnetic action of the current through a coil of wire on a piece of iron or on a magnet. A few of the more important ones will be mentioned below. The only ones differing radically were the Lippmann mercury ampèremeter, the Cardew voltmeter, and the Edison volt indicator, which is on the principle of a Wheatstone bridge, and the volt meters on the electrometer principle. The introduction of the latter, in a practical form, was the most important improvement in voltmeters. The most important ampèremeter for accuracy, reliability, and constancy is unquestionably the Thomson balance, which was not exhibited. Almost the same may be said of the Weston voltmeter, which was not exhibited either. All but direct reading instruments seem to have gone out of use.

Deprez-Carpentier.—Among the ordinary commercial forms not differing essentially in their general principle may be mentioned the following: The one meeting with most general favor, judging from the frequency with which one sees it used in France, is the form known as the Deprez-Carpentier, and exhibited by Carpentier. It

is merely a sort of galvanometer with an artificial field; that is, it consists of a soft iron pivoted needle under the combined action of a magnet and coil, placed with its axis slightly inclined to the usual position perpendicular to the field, to obtain a better deflection. They are arranged in a neat, convenient form, and are comparatively cheap, costing only $10. The ampèremeters may be supplied with conveniently arranged "reducers" (that is, shunts), which increase in a fixed proportion the value of the readings. Similarly the voltmeters may be supplied with an extra resistance (in series) to increase the value of their readings.

Desruelles.—In the form exhibited by Desruelles the needle is in the form of a small flat piece of soft iron pivoted so as to move like a weather vane or a flag against the action of a spring. It moves in a cylindrical space in a coil, which is lined with a thin sheet of soft iron in the shape of an isosceles triangle bent around so that its apex almost meets the base. The attraction of the needle to the constantly increasing amount of iron opposite to the end of it gives a nearly proportional deflection through almost 180 degrees. They are of interest on account of their cheapness.

Patterson and Cooper.—Among the exhibits of Patterson and Cooper were the well known original Ayrton and Perry voltmeters and ammeters, which are merely galvanometers with an artificial field and a double-pivoted needle; one form of these is arranged with a commutator attachment so that it can be recalibrated with a standard cell. They also exhibited an ampèremeter or "engine-room indicator" for large currents, consisting merely of a small magnetic needle pivoted on horizontal pivots and weighted so as to give it a direction parallel and quite near to a thick bar of copper through which the current flows; the direct action of this current deflects the needle against the action of gravity; the counterweight is adjustable, enabling the readings to be varied; in another form it is replaced by a spring. One of these was shown as a registering instrument, chiefly for central-station work. The same makers also exhibited a small pocket voltmeter of the permanent magnet type, having the outside appearance and size of a pocket watch and weighing 6 ounces.

Cardew.—The same makers exhibited the well-known Cardew voltmeters, in which the heating of a stretched wire by the current measures the current. They are too well known to require description here. In the later form the fine, stretched platinum silver wire of .0025 inch diameter is heated by the current for many days before calibration, to insure its remaining constant. The wire is protected by a very fine platinum wire fuse. They are usually made for 120 volts, reading through 360 degrees of the dial, and are one of the few voltmeters which are applicable alike for continuous and for alternating currents, and which can be left in circuit continuously.

Ayrton and Perry spring instruments.—Messrs. Latimer, Clark, Muirhead & Co. exhibited the well-known Ayrton and Perry spring instruments, in which the underlying principle is that a small axial pull of a solenoid on a special form of spring will result in a greatly increased rotary motion of the end of this spring. The spring consists of a helix made of a flat band of steel rolled around a long cylinder.

Alioth.—Messrs. Alioth & Co. (Swiss section) exhibited ampère and volt meters, in which a curved core was sucked into a curved solenoid. The construction is quite similar in principle to the pocket ampèremeter described and illustrated below. The core is in the form of a thin sheet of iron cut into a form like half of a new moon, pivoted at its center and connected directly to its pointer, which enables a deflection of more than 180 degrees to be used.

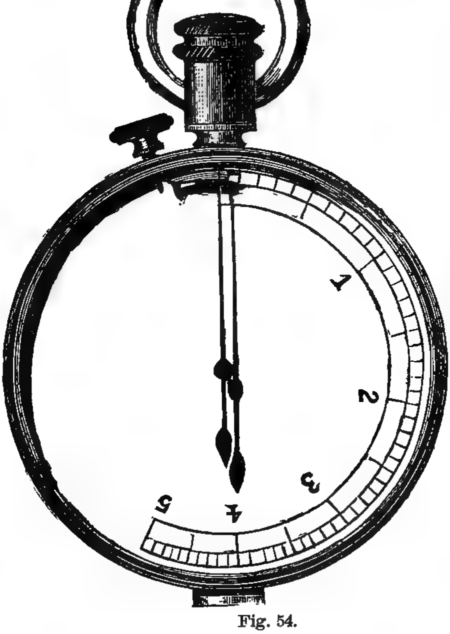


Fig. 54.

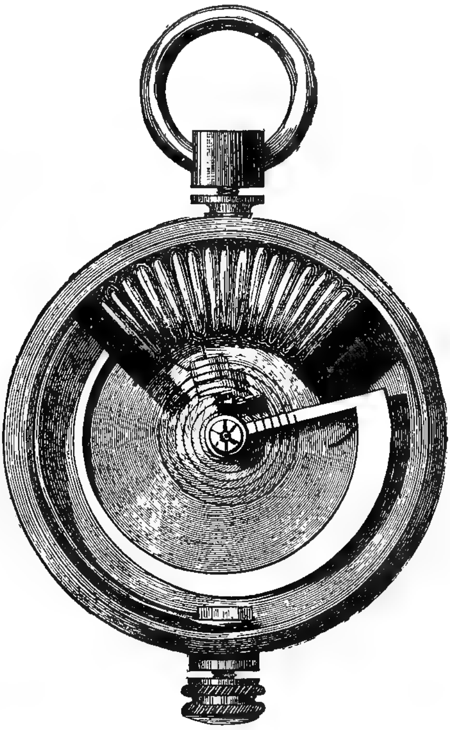


Fig. 55.

Pocket ampèremeter; Woodhouse & Rawson.

Pocket ampèremeter.—Messrs. Woodhouse & Rawson (French section) exhibited a very convenient form of pocket ampèremeter, having the external appearance of a pocket watch, as seen in the adjoining illustrations, Figs. 54 and 55, which show the face and the internal mechanism respectively. In principle it is the same as the Alioth form just described, the pivoted, crescent-shaped core at-

tached to the pointer being drawn into a curved coil, the counter action being a hair spring. Although probably not very accurate, it is very convenient, and will doubtless meet with favor for certain classes of work. It may, of course, be made equally well as a voltmeter.

Edison.—Edison exhibited a form similar in principle, but used chiefly for very great currents. The core is a round iron rod bent around in the form of a quadrant of a circle, and is pivoted on horizontal pivots at the center of this circle and counterbalanced by a weight. The fixed coil consists of a very coarse spiral of a few turns of thick, bare copper wire, also bent around in the form of a quadrant, so that the curved core moves axially through it. Its construction is certainly very simple, and for strong currents is probably very good.

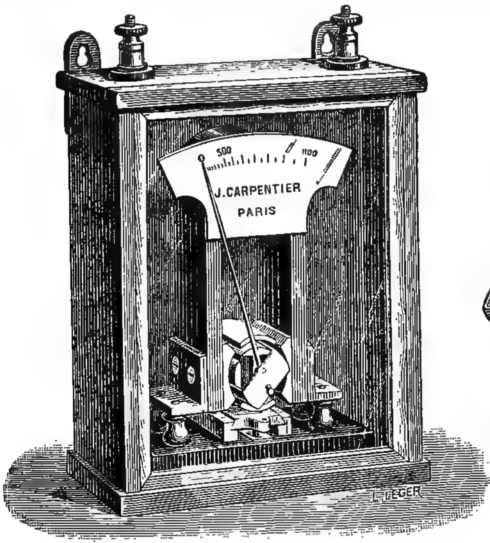
De Lalande.—Carpentier exhibited also a very simple form devised by Lalande and called an electric hydrometer, consisting of a long vertical solenoid filled in the interior with water, in which sinks an ordinary hydrometer, in the inside of which is a bundle of iron wires; this acts as the movable core which is sucked down against the buoyant action of the water, which replaces the spring used in the similar well-known Kohlrausch instruments. The range is quite large and nearly proportional in the portion most frequently used. The guide for this hydrometer, to prevent its attaching itself to the side of the coil, is under the liquid, whereby the friction is said to be eliminated. It is claimed to be nearly aperiodic (dead beat).

Thomson-Houston form.—In the one usually used by the Thomson-Houston Company (United States section) a small U-shaped piece of soft iron is pivoted near the center of a coil having a square cross section, three sides of which section are embraced by the soft iron piece. The tendency of the coil is to draw this piece closer to it, which it is enabled to do through a great range by the fact that the iron piece is pivoted eccentrically. The counter force is gravity. In the ampèremeters for great currents this coil is a circular piece of cast copper cut at one part and provided there with terminals.

Thomson's form for alternating currents.—A curious form devised by Elihu Thomson, for alternating currents, consists of a solid ring of copper situated in a coil, slightly inclined to it and capable of turning on the common diameter. The currents induced in this ring tend to move the ring into a position perpendicular to the coil. Gravity is the counter force. It is probably only experimental.

Electrometer form.—One of the most important improvements is the application of the electrometer principle to commercial voltmeters. One of these, made by Carpentier, is shown in Figs. 56 and 57. The movable part, shown enlarged in Fig. 57, is made in the form of a light rectangular frame of aluminum, rocking on knife edges

in the interior; it rotates so that its long sides move between the eight cylindrical segments, four inside and four outside. The four on a vertical diameter are connected together as well as to the needle and form one pole; the four others form the other pole. When in operation, the needle is repelled by the former and attracted by the latter, the counterforce being gravity. The function of the horseshoe magnets shown is merely to create an intense field through which the aluminum frame moves and by which its motion is dampened so that it is practically aperiodic. It is limited, however, to high voltages, from 500 up. Elliott and Bréguet also exhibited commercial voltmeters on this electrometer principle, resembling more nearly the Thomson electrometer, but with its axis horizontal and a



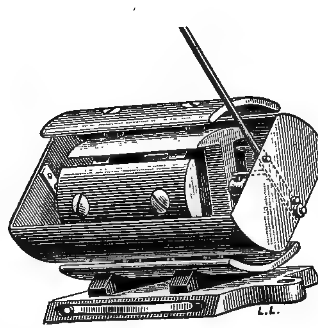


FIG. 57.

FIG. 56.

Electrometer voltmeter; Carpentier.

long pointer attached to its "figure 8" needle; these, however, are not aperiodic, which is an important objection, as they oscillate a long time. Those of Elliott are made for as low a voltage as 40, the range of this one being 40 to 160. The advantages of such voltmeters are that their constant is fixed and does not change, that they may be kept in circuit continually, are independent of temperature, and are equally applicable for alternating and for continuous currents.

Thomson standard balances.—The Sir William Thomson standard ampère balances were not exhibited. They are, however, of too great importance to be passed by here without a short description. The object of the instrument is to measure current by devices which remain absolutely constant, which are entirely independent of any sur-

rounding or variable conditions, and which are transportable. It is, in fact, a transportable standard ampèremeter, and belongs to the same class of instruments as the standard ohm, the standard cell, and the absolute electrometer. The principle is that the attraction of the current to itself is measured by being balanced by a weight. The apparatus consists in general of a pair of balances having two flat coils in place of the scale pans. Immediately below each of these there is a fixed coil, axial with the one above. The current passes through all in series in such a direction that two of the coils repel each other and the other two attract, thereby turning the balance. This force is exactly counterbalanced by an adjustable weight sliding on the beam; its position measures this force and therefore the exact current. Their chief commercial use is to serve as a standard in calibrating (by means of a standard resistance) the ampère and volt meters of commerce. They are not intended to replace these. In the newest forms, the range of each instrument is 100 times the smallest unit. The smallest is for 0.01 to 1 ampère and the largest from 25 to 2,500 ampères. Their prices are about $150.

Converter-voltmeter.—Elihu Thomson also exhibited an experimental electrometer voltmeter for low potentials, in which the electrometer was connected to the secondary circuit of a small transformer in which the low potential was converted into one sufficiently high to be measured by the electrometer. This is for alternating currents. For direct currents the transformer was made of a series of condensers like those used in the well-known Planté experiments, which are charged in multiple arc and discharged in series by means of the usual cylindrical commutator, which is rotated rapidly.

Edison voltmeter.—The portable voltmeter used and exhibited by Edison differs essentially from most others. It is in principle a potentiometer, that is, one in which the difference of potential is compared with a standard cell and is measured in terms of that cell, which is contained in the voltmeter as part of it. It consists essentially of a high resistance whose ends are connected to the two points whose difference of potential is to be measured. A standard cell in series with a small galvanometer is connected, as a shunt to a small portion of this resistance, by a sliding contact moved until no current flows through the galvanometer. The required voltage is then a certain multiple of that of the cell. The graduations at the sliding contact are so calibrated as to read directly in volts. The standard cell is a Daniell, made in the form of a small U-tube, having the bend filled with plaster of Paris, and the metals with their respective solutions in the two limbs. The plaster acts as a porous diaphragm and prevents the mixing of the solutions for three or four months. It is air-tight and cheap and is replaced by a new one when used up. They are also made with Clark cells, which appear to be better. The same apparatus is arranged to enable currents or high insulations to

be measured with it. Their standards for calibrating all their instruments are the Daniell and the Latimer Clark cells (1.435 legal volts at 15° C.) and the legal ohm.

Edison volt indicator.—The Edison volt indicator differs also in principle from the usual instruments, the principle being that the potential is measured by the change of resistance of the carbon filament of a lamp through which the current passes. It is used in multiple arc distribution merely to indicate the normal potential and a few volts on either side of it.

It belongs to the class of "zero" instruments, and consists, essentially, of a sort of Wheatstone bridge, as shown in the adjoining illustration, Fig. 58, in which an incandescent lamp forms one of the arms of the bridge, the three other arms being ordinary resistance coils. The usual battery is replaced by the leads at which the potential is to be measured. A small galvanometer with an artificial field (so as to be independent of the earth's magnetism) is contained in the apparatus and has a long pointer with a black disk on its end moving over the scale, so that it is readily visible even at a distance.

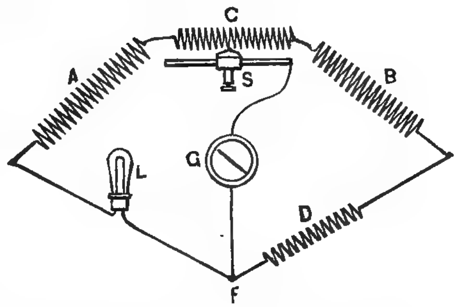


Fig. 58.—Edison's volt indicator.

The system is so arranged that at the normal voltage it is balanced and the galvanometer points to zero, which is marked as the normal potential. If the voltage changes, the current through this lamp will change, which in turn changes its resistance correspondingly, alters the balance of the bridge, and deflects the galvanometer needle. By this means a change of one volt from the normal may be made to deflect the end of the needle half an inch, which can therefore be seen at a comparatively great distance. A small adjustable resistance is added so that the instrument may be adjusted to any desired voltage as a normal. It is to be kept in circuit all the time, one of the resistances being made partly of German silver and partly of copper so proportioned that as they heat up the balance is still maintained. An objection to these instruments is, that the current required by them is great enough to be affected by the resistance of the pressure wires leading back from the points of distribution.

Compound voltmeter.—Messrs. Cuenod Sautter & Co. (Swiss section) exhibited an ingenious voltmeter of some interest, for the following special purpose: In multiple-arc distribution in which mains are led to a central point of distribution it is desired to measure, in the station, the potential at this distant point, thus eliminating the variable loss of potential in the mains. This is usually done

by running small potential wires from this point back to the station. These involve no insignificant first cost and cost of maintenance.

The object of this voltmeter is to dispense with these, enabling the desired potential at the far ends of the mains to be read directly from their dynamo ends. It consists of an ordinary voltmeter which has in addition a coarse coil for the main current, the magnetism of which opposes that of the fine wire coil and reduces the deflection by an amount which corresponds to the number of volts lost in those mains. As the magnetism of this coarse coil is proportional to the current the deflection will be reduced correspondingly for any current in the mains. It must, of course, be adjusted for the particular mains for which it is to be used, and it can not be used for any others.

Lippmann ampèremeter.—The ampèremeter of Lippmann, sometimes called the "mercury ampèremeter," exhibited by Bréguet, differs entirely in principle from the ordinary ampèremeters, and has some very good features. Although made in a commercial form, it will hardly replace the ordinary cheaper ampèremeters, but for special cases it has very great advantages. The scale is absolutely proportional, there is no heating error for large currents, and it is aperiodic.

The principle is that a conductor traversed by a current and situated in a magnetic field, normally to the lines of force, will be moved in a direction parallel to itself and perpendicular to the lines of force, and with a force proportional to the product of the current and the intensity of the field. In so far it is similar in principle to the wires on an armature of an ordinary motor. The application of the principle, however, is quite different. A U-shaped tube partially filled with mercury is placed with the bottom part of the bend between the two poles of a powerful horizontal magnet, the field of which is perpendicular to the column of mercury in that part of the tube. The current is then made to pass transversely through this portion of the mercury column—that is, across the column perpendicularly to both the field and the axis of the horizontal column at this point. The repelling force of the current will then cause the mercury to be displaced in the direction of its axis, making it rise in one arm of the tube and fall in the other. This rise or fall will be directly proportional to the current throughout the whole range, which latter is limited only by the heating of the small section of mercury through which the current passes, and which, in practice, is made in the shape of a small parallelopipedal space bounded on two sides by the poles of the magnet and on the other two by the platinum contact plates for the current.

If the strength of this field is known the displacement per ampère can be calculated and the instrument thereby calibrated. This displacement in centimeters is equal to the product of the current in ampères, and the field intensity in c. g. s. units, divided by 133,416 times the thickness in centimeters of that part of the mercury col-

umn which is between the magnet poles, measured in the direction of the line of force. It is independent of all other factors and dimensions. With a thickness of one-tenth of a millimeter the greatest sensitiveness produced was 14 centimeters per ampère, the field being 18,678 units. Ordinarily the sensitiveness is from 6 to 12 centimeters per ampère. Others have been made to read up to 1,000 ampères, the permanent magnets being replaced by an electromagnet.

Maximum and minimum voltmeter.—For a maximum and minimum voltmeter, see Deprez galvanometer, under the heading "Galvanometers."

Recording ampère and volt meters.—Richard Frères (French section, gold medal) exhibited a number of their registering ampère and volt meters, which appear to be coming into use quite largely. They are very convenient and quite simple in construction; though not very accurate, they are sufficiently so for many purposes and they will doubtless find great application. A registering ampèremeter for strong currents is shown in the adjoining illustration, Fig. 59.

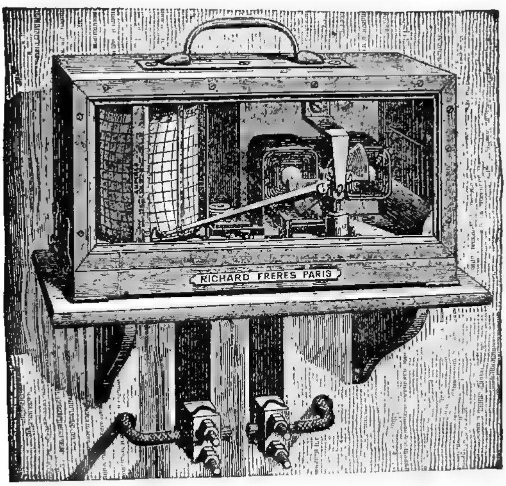


FIG. 59.—Registering ampèremeter.

The galvanometer part is of somewhat crude construction; the two-winged, soft iron armature, shaped somewhat like a butterfly, is pivoted on horizontal pivots and is connected to the pointer; it is so shaped and bent that the deflection is as nearly as possible proportional within the greater part of the range of motion; gravity is the opposing force. The end of the pointer carries the ink in a small receptacle, the point of which acts as a pen. The revolving cylinder contains its clock and turns once in twenty-four hours, the paper for it being printed with the required curved cross hatchings and duly

numbered with hours and ampères. It is not necessary that the galvanometer needle be moved with great force, as the fact that the paper moves enables the pointer to overcome the friction at the pen, even though the force is small, only it will not act as promptly. The same recording drum is used by these makers in many of their meteorological recording instruments, which see for a more complete description.

References.—For a voltmeter and a milliampèremeter, see also Deprez d'Arsonval galvanometer under the heading "Galvanometers."

METERS.

The exhibit of meters, though not as full and complete as might be desired, was fairly good, but it can not be said to be even a fair representation of the present state of the art. Most of the meters were French and were characterized by their complicated construction, though some of them are doubtless very good notwithstanding. There were two from the United States and one each from England and Switzerland. With the exception of the Edison meter, they were mostly new, from four to five years back; this branch may, therefore, be said to have developed almost entirely within the past few years. The majority of the exhibits were simply ampère-hour meters, though many are incorrectly called watt meters, their constants being determined for a certain potential which is assumed to remain constant.

Among the French meters the electro-dynamometer is used almost exclusively as the measuring instrument. Among the rest only few novel or interesting points were shown.

Among the difficulties encountered in designing meters are that, for small currents, and often for no current at all, the meters record inaccurately; although the current is small yet the *time* of these small currents in most cases covers the greater part of the day; the product of the two is, therefore, not always insignificant. The writer has noticed one of the best meters exhibited, record current when the circuit was open. Another difficulty is in the clock mechanism when used. A wound-up spring or weight represents so very little energy that it can be used for no work other than to run a pendulum or escapement; if more is required of it, it either needs to be wound up very frequently or else it must be impractically large. It is, therefore, often replaced by an electric-motor device, but this introduces make-and-break contacts, and it is a question which is worse. Although there are at present good meters in the field, yet none of them combine all the desired qualities of simplicity, reliability, accuracy, and cheapness. There is, therefore, much to be looked for in this branch.

In the following description they are divided into watt-hour meters (true), ampère-hour meters, and time meters:

WATT-HOUR METERS.

Cauderay-Frager.—The Compagnie pour la fabrication des compteurs (French section, silver medal) exhibited the Caudray-Frager meter, which is perhaps one of the best known and most frequently used meters in France. It is a watt meter, for alternate as well as continuous currents. In details it appears to be altered frequently, as descriptions and models differ; the general principle, however, is about the same.

The following description is that of one of the latest forms: The current and potential are measured by an electro-dynamometer, the fine wire, movable coil of German silver for the potential, and the large coil encircling it for the current. The movable coil is suspended by a torsion wire; the true values corresponding to the deflections are recorded on a counter every 100 seconds, as will be described. The usual clock work for determining the time is here replaced by a sort of electric clock, the object of which is to turn a horizontal disk continuously on a vertical axis so that it makes one revolution every hundred seconds. This disk is concentric with the shaft of the counter, but is not connected to the same. It has numerous ratchet teeth around its circumference over which is an arm from the shaft of the counter; this arm has a catch, and when depressed it engages with these teeth and is carried around with the revolving disk; thus, as long as this catch is depressed the shaft of the counter is being turned with the disk, and a corresponding angular movement is recorded on the counter.

The remaining part of the meter has for its object to depress and hold down this catch for a length of time corresponding to the true value of the deflection of the electro-dynamometer at that moment. This is accomplished as follows: A portion of the revolving disk is raised slightly above the rest; this portion may, at present, be assumed to be a sector of the disk, with straight, radial edges; the end of the pointer of the electro-dynamometer which is free to move, is directly above this disk, and its movement when deflected is from the center to the circumference of this disk, the former being its zero position and the latter the position of greatest deflection; when, in the rotation of the disk, the sector passes under the end of the pointer it raises it slightly, and, by a simple spring lever, depresses the catch above mentioned, which locks the disk to the shaft of the counter; the turning of the disk is therefore recorded on the counter as long as that sector is moving under the pointer, which length of time will evidently depend on whether the pointer is near to the small end or to the large end of the sector. As soon as the edge of the sector has passed from beneath the pointer, the latter as well as the lock catch are released, and the moving of the counter is stopped; this takes place once in every revolution of 100 seconds.

It was assumed above that this raised sector had straight radial edges; this would be the case approximately if the deflections of the pointer were proportional to the watts; but as this is not the case, the sector is made with the outline of one edge curved, the nature of the curve being such that the width of the sector at all points is proportional to the true value of the watts for the corresponding position (deflection) of the pointer. This curved edge therefore admits of correcting any error in the proportionality. It therefore admits of placing the electro-dynamometer coil at an angle, for its zero position, in order to increase its sensitiveness; the best angle is said to be half that of the angular range of deflection allowed.

The electric clock mentioned above is an important part of the meter. It consists essentially of a large, heavy escapement wheel and spiral spring, on a vertical shaft, turning alternately to the right and left, and beating seconds. The vertical shaft of this wheel is a flat bar of iron, which turns on its axis between electro-magnets, of which it forms the armatures. Momentary currents in these magnets, when properly timed, will turn this iron armature and thereby oscillate the escapement wheel. The connections for these momentary currents are made by means of a peculiar device, which closes a contact only when needed; that is, when the wheel is not making its full oscillations of half a turn.

The contacts are double, in multiple arc. one being slightly in advance of the other, by which means one of them always remains clean, as there are no sparks produced on the one that opens first; besides this there is a slight friction produced at each closing of the contacts.

They state that during the past year they have never had a case of stoppage due to unclean contacts among 250 meters.

The following figures given by the makers may be of interest: The resistance of the fine-wire bobbin is 2,800 ohms; the temperature error is less than 1 per cent for a range of 20° C. The total maximum error of the whole meter is said to be 3 per cent, while the mean error is about 2 per cent. Below one-tenth of the maximum current of the meter the error becomes larger, it being 35 per cent for a current equal to one one-hundredth of the maximum.

The energy consumed by the meter is given as follows: In the fine coil, 3.5 watts; in the clock, 1 watt; together, equal to one one-thousandth of the total capacity; that in the coarse coil is 5 watts, at the maximum current, making a total of 9.5 watts. The current for the clock is required only every 10 to 12 seconds, for one-quarter of a second, requiring therefore 9 coulombs per hour.

They have had their meters in use for four years, and at present have five hundred in use. The sales during the past two years have amounted to $20,000, and their monthly sales at present amount to $3,000.

Blondlot.—The Blondlot meter exhibited by Henrion (French section), is a true watt meter for alternating or continuous currents. It is simple in both principle and action, and belongs among the better ones of its class.

The current is measured in an electro-dynamometer the series coil of which is quite large so as to produce a uniform field at its center. The deflections of the fine-wire coil are made proportional to the product of the current and the potential, by means of a cam on its axis, over which passes a string with a counterweight. The curved surface of this cam is such that the angular deflection will be proportional to the watts.

The deflected coil is brought back to zero by an electro-magnet, at regular intervals of time determined by a clock which closes the magnet circuit. The angles through which it is moved back are recorded on a counter, as follows: The main axis of the counter is directly opposite to and in line with that of the movable coil of the electro-dynamometer, but normally it is not in contact with it. On the shaft of the counter is an electro-magnet whose armature is on the end of the electro-dynamometer axis, so secured as to allow it to approach toward the magnet; when this magnet is excited the two shafts are thereby coupled together. The current for this magnet is closed during the interval when the other magnet moves the electro-dynamometer coil back to zero; these angles are thereby all recorded and summed up on the counter.

There were a number of others, such as the Clerc, Gravier, Mildé, and Chambaud, which were somewhat similar in principle to these; some with self-winding clocks; some in which zero readings only were used. No good description of these could be obtained.

Brille.—The Brille meter, exhibited in the central station of the French Edison Company, is a true watt meter for continuous currents, and, it is claimed, may be arranged for alternating currents also. It is simple in principle but somewhat complicated in construction, though its complication is not of such a nature as to be likely to make it unreliable.

In its principle it belongs among the better class of watt-hour meters exhibited. Owing to its complicated construction it can be described here in principle only. The current and potential are measured by an electro-dynamometer, the coarse fixed coil of which is for the main current, and the fine wire movable coil for the potential, the counter force for the latter being obtained from a special spring; the deflecting force is proportional to their product. Every 36 seconds (one-hundredth of an hour) the deflected coil is moved back to zero by turning the torsion head or free end of the counter-spring, the angle through which it is turned being recorded on a suitable counter with dials.

The rest of the apparatus consists of a clockwork which starts the mechanism every 36 seconds, and a motor which moves the coil back

to zero and which rewinds the clockwork after every reading; an additional device starts the pendulum of the clock should it have come to rest by a stoppage of the current. The motor consists simply of an electro-magnet having three iron armatures, one for moving the coil back to zero, one for rewinding the clockwork, and one for operating a contact. This magnet is put in circuit every 36 seconds by the clockwork and is cut out when the whole cycle of operations is finished. The various operations are determined by several sets of contacts which make or break the fine-wire current.

This is probably the weak point of this meter, as a current of such high voltage and with such self-induction coils in circuit can not but give a spark, which in time must affect the contacts and require them to be cleaned. In order to properly measure and integrate the angles through which the spring of the coil is turned to bring the coil back to zero, the lever arm which turns it must move with a constant velocity; this is accomplished by a fan escapement and an ingenious friction governor.

By properly proportioning the parts, the constant of the instrument is readily made unity so that the reading is direct in watt hours. It will be noticed that in principle it is a true watt meter, and that such factors as friction and temperature are practically eliminated. It is suggested also to run the clocks of all meters in a plant by a special circuit, in which case the apparatus is simplified and it may then be used for alternating currents also. A very good illustrated description will be found in La Lumière Électrique, August 18, 1888.

Aron.—The Aron meter for continuous currents, exhibited by Danzer (French section), consists essentially of two 40-day pendulum clocks with independent works and pendulums adjusted to run absolutely alike. The current retards or accelerates the motion of one pendulum while the other moves unobstructed; this causes a difference in the running of the two clocks, which difference is measured and recorded by a simple five-dial counter, the readings of which are said to be proportional to the quantities to be measured. The counter is operated by a planet movement, and registers only the difference in the running of the two clocks.

The electrical part is different, depending on whether it is an ampère-hour meter or a watt-hour meter. In the former, one of the pendulums has at the bottom a steel magnet, which, by the oscillation of the pendulum, moves to and fro over a fixed solenoid through which the main current passes; the relative action is an attraction, which accelerates the oscillations of that pendulum, causing a corresponding difference between it and the other. It can evidently be used only for continuous currents.

For the watt meter, the bottom of the pendulum carries a fine-wire solenoid, connected as a shunt across the mains; this moves axially to and fro through the interior of a large fixed solenoid through

which the main current passes. The mutual action between the two coils is proportional to the watts; the effect on the pendulum will therefore depend on both the volts and the ampères, and is said to be proportional to their product, the watts.

The readings of the counters are said to be proportional to the ampère hours or watt hours, but they must be multiplied by an empirically determined constant to reduce them to ampère or watt hours. They appear simple and reliable, but it is a question whether the readings are truly proportional for wide ranges of current.

Boiron and Cozette.—In this meter (French section) a small shunt-wound dynamo drives a fan escapement. A set of dials integrates and indicates the number of revolutions. It is called a watt meter. Apparently the main current passes through the armature, and the potential current through the field. It is probably only experimental.

For other watt-hour meters, so called, see under ampère-hour meters below.

AMPÈRE-HOUR METERS.

Any ampère-hour meter may be, and often is, used as a watt-hour meter by assuming that the potential remains constant, in which case the meter may, and correctly too, be made to read in watt hours or energy, in place of ampère hours or current quantity. In a technical classification like the present, however, they belong strictly to ampère-hour meters, and are therefore classed under this heading.

Hookham.—The Hookham meter (English) was exhibited by the Compagnie Électrique (French section). The principle is exceedingly simple and is essentially as follows: The current to be measured drives a small electric motor which moves a solid disk of copper through a magnetic field which therefore acts as a brake or counterforce. The stronger the current, the faster the motor will tend to move, but at the same time, the greater will be the counterforce of the brake. The conditions are so chosen that the resulting speed will be proportional to the current. The revolutions of the shaft are transferred to a simple counter with dials. It is therefore an ampère-hour meter for continuous currents only, but it is made to read directly in board of trade units (kilowatt hours) by assuming a constant difference of potential of 110 volts for instance.

The construction is quite simple and ingenious. The armature is in the form of a thin flat disk of solid copper, on one side of which are secured the radial armature windings, interconnected at their outer and inner ends so as to form a simple armature winding. The whole forms a thin flat disk. The current passes through these windings by means of two commutators or collectors revolving in two mercury troughs. The solid copper disk revolving with it, generates in itself Foucault currents which oppose the revolutions, thereby acting as a counterforce. If the field is constant, this opposing force varies as

the velocity, while the force to turn the motor varies as the square of the velocity. The resulting velocity will therefore vary as the current, and may therefore be used as a measure of the ampère hours.

The field magnet is a permanent magnet made of bars of steel and tungsten inclosed in a brass tube and secured to two pole pieces, between which the armature revolves. The field, or space between these pole pieces, through which the disk armature moves, is very short or thin in order to keep the field as strong and as constant as possible, as the principle of this meter depends on the constancy and strength of this field. These magnets are made with great care, and they are said to have been found to remain constant in a large number of meters after fifteen months of use. It is said that they are made constant by magnetizing them and then reducing their magnetism by about 10 per cent, so that their tendency will be to strengthen rather than to weaken. The conditions are so chosen that the effect of other retarding forces may be neglected. The armature revolves quite slowly. There is no oiling necessary, as the shaft rolls on disk wheels, which themselves roll on others, which again roll on a third set.

If the proportionality of the current to the revolution, and if the constancy of the field are what is claimed, it appears to be a very good and simple meter, for the purpose for which it is intended.

Jacquemier.—The Jacquemier meter exhibited (French section, silver medal), is an ampère-hour meter for continuous currents. It is too complicated to be described here, except in principle. It contains many levers, springs, gears, etc., of a complicated and delicate nature, which is one of its weak points.

The current is measured in an electro-dynamometer, the fine wire movable coil of which is an electro-magnet and is in shunt circuit to the mains; its magnetism is assumed to be constant, and the apparatus is therefore a galvanometer. This coil is deflected against the action of a double spring, a light one for small displacements and a strong spring for the larger ones.

There are two clockworks running fifteen days, one for determining the intervals of time of five minutes at which the measurements are made, and the other to do the work of recording the deflections. Every five minutes the former starts the latter, which operates a delicately-balanced searching lever, which moves toward the deflected pointer of the galvanometer; the moment the lever touches it, it is thrown out of balance and the second clockwork is thereby stopped at its fan escapement; the path which it has traveled before it touches the pointer is registered on the counter by the clockwork. After this the clockwork brings the parts back to their normal position.

The deflections are not proportional; this is corrected in the registering apparatus by a train of gears, two of which are not circular,

but have an irregular periphery. There are no contacts made or broken, which is a favorable feature.

Aron.—See under the watt-hour meters.

Edison.—The Edison meter is too well-known to need description here. It is essentially a zinc voltameter and measures coulombs, or ampère hours and is for direct currents only. For a well-illustrated paper on this subject see that of W. J. Jenks, American Institute of Electrical Engineers, December 18, 1888.

Alioth.—The Alioth meter (Swiss section), measures ampère hours. A core moves vertically in a solenoid. A 40-day clock drives the counter through a simple intermediate mechanism which depends on the position of the core in the solenoid. The farther the core is drawn into the solenoid the faster the counter is driven by the clock-work. The inequality in the proportion of the current to the movement of the core is corrected by a corresponding curved piece in this intermediate mechanism.

Heinrich & Mulberger.—An electric clock drives a train of gears; a Deprez galvanometer, presumably for the main current, operates on a pulley of this gearing by means of a string and weight which act as a variable brake. Presumably the difference between the normal speed and the retarded speed of this pulley integrates the ampère hours, which are indicated on dials. It is probably only experimental.

Thomson.—The meter exhibited among the apparatus of Prof. Thomson (United States section) is for alternating currents only. The main current passes through a transformer in the meter; the secondary current of this transformer is the one measured in the meter.

The meter consists of a horizontal glass tube with two vertical bulbs at its ends like a so-called "pulse glass." This rocks about a center like a scale beam. The tube and bulbs are partially filled with a volatile liquid; above the liquid in each bulb is a small coil through which the current passes and which is thereby heated. First, one of these is heated by the current, which then causes the liquid to move into the other bulb; this causes the beam to tilt over to the other side, which then switches the current by means of mercury contacts to the other coil, which in turn forces the liquid back and causes the beam to tilt again. This rocking of the lever is registered on suitable dials, which read in watt hours.

In the transformer there is an additional coil of fine wire, the terminals of which are across the mains, the current in which is therefore proportional to the potential of the mains. The function of this is presumably either to make the meter measure the volts also, and therefore the watts, or else, and more probably, it is to introduce a constant force to overcome the friction and similar losses in the apparatus, the potential being assumed to be constant.

Borel.—The Borel meter (Swiss section, bronze medal) is an ampère hour meter for alternating currents only. In the latest form it consists essentially of two flat bobbins in multiple arc, whose core space has a cross section of a flat, oblong rectangle. These are mounted, side by side, so as to have a common axis. In the flat rectangular core space is a thin flat disk of iron capable of revolving about a vertical axis and acting as an iron core common to the two coils. There are also two straight iron bars running through the two coils parallel to the axis, and almost tangential to this disk, but not touching it; their alternate ends project and are bent over. These iron bars and the iron disk are both magnetized by the alternating current, but owing to their shape, position, the Foucault currents produced in them, and hysteresis, the magnetic phases will differ in such a way as to produce a continuous repulsion and consequent rotation of the disc in one direction; this rotation is used as the measure of the current and is transmitted to a counter with dials. On the same axis are secured a set of four fans which act as the opposing force. Their resistance in the air is proportional to the square of the velocity; the rotating action is said to be approximately proportional to the square of the current. On account of the want of true proportionality, two of the four fans are hinged at their top edge so as to offer less resistance as the speed increases. In this way a proportionality is said to be secured between certain limits.

From published results it appears that it is not very reliable and accurate. It is said to be used at the Ferranti Station. Two hundred are said to have been in use in Nancy for a year. A good and well illustrated description of an earlier form will be found in La Lumière Électrique, July 14, 1888, p. 53.

TIME METERS.

Aubert.—The Aubert meter (Swiss section, honorable mention) is simply a time meter, to measure and integrate the number of hours during which the current has been turned on. It is of use merely for constant currents, but for such it appears to be good, simple, and cheap. It consists of a clockwork running 200 hours. It indicates on four dials the minutes, hours, tens and hundreds of hours. It is a simple clockwork, the escapement of which is released by a magnet when the current is started. There are said to be over two thousand in use. It sells for only $7. It is equally good for alternating as for continuous currents.

MISCELLANEOUS MEASURING INSTRUMENTS AND APPARATUS.

Standard cell.—In the educational department (United States section) was shown a standard Daniell cell devised by Carl Hering, the object of which is, to have a simple form of cell which is always ready without being refilled every time it is to be used, and in which the

liquids, which must necessarily mix at their junction, are drained off at their junction faster than they can mix, thus preserving the two liquids absolutely pure. The arrangement is shown in the adjoining illustration, Fig. 60.

It consists of two bottles containing the two liquids and their respective electrodes. They are joined together at the bottom by means of a three-way tube having stopcocks and containing some filtering paper or other porous material to prevent too rapid flow of the liquids. The third tube communicates with the air from the junction and through this the mixed liquid at the junction is drained off drop by drop faster than it can mix. When not in use the cocks are turned to prevent waste of the liquids.

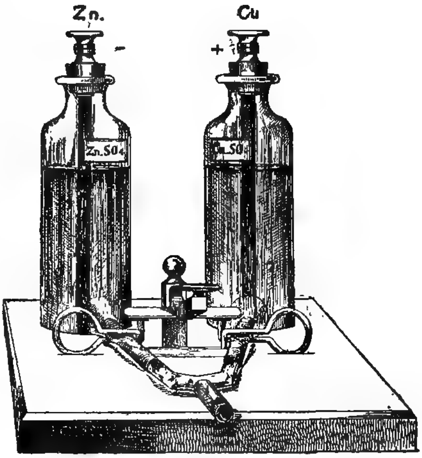


FIG. 60.—Hering's standard cell.

The electromotive force of such a cell, with solutions of pure copper and zinc sulphates, both having a specific gravity of 1.20 at about 60° F., using pure electroplated copper and pure amalgamated zinc, is 1.105 true volts.

Pyrometer.—Carpentier exhibited an electric pyrometer devised by M. le Chatelier, which appears to be a very satisfactory instrument, and which is said to be used largely; it is very conveniently arranged, considering its accuracy and range.

It consists of a thermo-couple connected directly to a galvanometer. The electromotive force of this couple increases with the temperature; the current through the galvanometer is, therefore, a direct measure of the temperature. The thermo-couple is made of platinum and platinum-iridium alloy of 10 per cent, which gives good results up to 1,200° C. or 2,200° F.; it is at the end of a long rod by which it is introduced into the furnace. The galvanometer is of the Deprez-d'Arsonval form (which see under galvanometers) arranged in a very practical form with lamp and scale, so as to be portable; it is in the form of two flat boxes, one containing the galvanometer and the other the lamp and scale; to use it, these two boxes are hung on the side of a wall one meter apart. The apparatus gives a deflection of 10 centimeters (4 inches), for 1,000° C. (1832° F.)

For an illustrated description see La Lumière Électrique, June 30, 1888, p. 604, which article contains also descriptions and references to descriptions of other pyrometers.

Photometer.—Messrs. Patterson & Cooper (British section) exhibited a photometer devised by Thompson (S. P.) and Starling. It differs from the ordinary photometer in the following points: That the paper with the grease spot is replaced by two disks of plain white paper at an angle to each other, so that both can be seen at the same time, the one being illuminated by the candles and the other by the light to be measured; the screens and the lamp are fixed and the candles moved; two candles are used to eliminate partially the errors in the candles.

It is arranged in a very convenient form so as to facilitate readings, the scale being so spaced that the readings are direct, even for very high candle powers; the only reductions are multiples of 10. The correction for a mirror which is used for bright lights is made by the constructor in fixing the space between the lamp and screen. The whole arrangement of the photometer is very convenient, but it is doubtful whether its accuracy is as great as in the ordinary form, as a number of slight errors appear to be introduced by this construction.

Magnetic and fluid bridges.—Edison exhibited his magnetic bridge, the object of which is to enable one to measure the magnetic properties of samples of iron to be used for dynamos.

It is based on the principle of the Wheatstone bridge, in which the electric current is replaced by the magnetic flux. The battery is replaced by a large magnet, and the galvanometer is replaced by a magnetic needle, which is situated between the two points where magnetic balance is to be reached. The three arms of the bridge are of fixed pieces of iron while the fourth is made of the sample to be tested. No means are given for bringing the needle back to zero, that is, for producing balance. The samples of iron are so short that the magnetic resistance at the two contacts forms perhaps the greater part of the whole resistance to be measured. While it is ingenious in principle it is probably of little use in practice for the reasons given.

Edison also exhibited a fluid bridge, the object of which was to measure the resistance of liquids, the principle of which was also that of the Wheatstone bridge. Both of these are no longer new.

Tasimeter, etc.—Edison exhibited a number of instruments for different purposes which depend for their action on the change of resistance of a carbon button under variable pressure, this variable pressure being produced by different substances. In the tasimeter, for instance, it was produced by a piece of hard rubber, and was used as a means of measuring very small differences of temperature, as, for instance, that of the heat from a star. The expansion of the hard rubber compresses the button. In a hygrometer this was made of gelatine which expands by absorption of moisture.

Thomson's apparatus.—By far the most interesting and novel apparatus for scientific researches and demonstrations was the alternating current apparatus of Prof. Elihu Thomson (United States section, grand prize). It attracted very great interest among scientists as among technical engineers, and owing to the striking phenomena it was interesting even to the general public. The apparatus and the phenomena, though new, have been so thoroughly described in the American techical journals, that it is needless to repeat a description here.

The main phenomenon, which Thomson no doubt was the first to notice, is briefly as follows: If a closed metallic circuit, such as a ring, sheet, or other mass of copper, be brought near a coil in which an alternating current passes it will be repelled from the same.

The explanation is, briefly, that a current is induced in this mass of copper which at one instant is attracted and at another instant is repelled from the original or primary current. These attractions and repulsions would be equal and would therefore balance if the secondary current flowed without retardation, but owing to the fact that the secondary current is retarded in its flow by self induction, the repelling force becomes greater and the attracting force less, and there is therefore an excess of the former, or in technical terms, the waves of the two currents differ in time by a fraction of a wave length, thereby causing a preponderance of the repelling force over the attracting force.

This phenomenon was shown by several striking experiments. A solid ring of copper held over the end of an alternating-current magnet was kept floating in the air above the magnet by this force. When forced down over the magnet and then released it was projected up into the air. A hollow sphere of copper was floated in a tank of water placed over this magnet, and when a sheet of copper was placed between the magnet and the ball so as to cover half of the end of the magnet, the ball would rotate rapidly and with considerable force; the copper sheet acts as a screen to cut off the action from one half of this sphere, the other half being continually repelled, causes the sphere to revolve.

A number of applications of this principle of repulsion were shown, one of which was an alternating current motor, which see under "Dynamos."

Another apparatus of interest exhibited by Thomson was an instrument for studying the waves of alternating currents. It consists essentially of an iron diaphragm, opposite to an electromagnet, through which the current to be studied passes. Its motion is communicated to a small mirror by a lever, which also enlarges the motion. A beam of light is reflected from this mirror on to a ground-glass plate, on which, therefore, a line would be produced, when the mirror oscillates, by the action of the alternating current.

This line becomes a "figure-8" shaped diagram when the whole apparatus, except the glass plate, is moved rapidly to and fro by hand.

In another form the mirror is under the action of two magnets, giving to it a motion in two directions perpendicular to each other, by which the relative action of the waves of two currents, primary and secondary, for instance, can be studied.

Influence machines.—Influence or induction machines for generating electricity of very high tension and small quantity, often called static electricity, were exhibited by numerous makers. They were all of the "induction" type, in which the electricity is generated by the static induction of one electrified body on another, as distinguished from the original Franklin friction machines, which exist now only as historical apparatus. Most of them were of the well known Wimshurst type and a few of the less frequently used Holtz and Carre type. The former seem to be replacing the others rapidly, as they have numerous advantages in simplicity and in their action, being, it is said, affected less by humidity, and will not lose their charge, like the Holtz type.

The finest exhibit of a Wimshurst machine was that of Ducretet (French section), which had twelve glass plates, 26 inches in diameter, giving sparks 10½ inches long, at the rate of one or two per second. It is said to be the largest one ever built. The finer ones are always inclosed in glass cases. In some cases the glass plates are replaced by hard rubber, which is much more durable, as the glass is likely to crack and burst. They are used chiefly for demonstration purposes, but they have lately come into use largely for testing cables during their manufacture. They are also used largely for medical purposes.

Geissler & Crook's tubes.—The principal exhibits of Geissler & Crook's tubes were those of V. H. Seguy et Fils (French section, bronze medal), and M. Anselme (French section, honorable mention), both of which were very creditable exhibits.

Speed register.—Bréguet exhibited a speed register of Duveau. Its description does not belong here, as it is not electrical, with the exception of one feature of particular interest, which is applicable also to other apparatus, notably to chronographs. This is a small electric motor, whose speed is absolutely constant, no matter how much the current which drives it varies. It consists of a small four-pole frame and a Siemens H armature. The current driving it is alternated by means of contacts on a tuning fork, which is kept vibrating by the usual electric apparatus. The speed of the motor must synchronize absolutely with the alternations of the current, as it will run only under those conditions. As these alternations are produced by the tuning fork, the speed of the motor is as constant as the vibrations of the tuning fork, and is entirely independent of the strength of the current.

Binding posts.—For a description and illustration of some binding posts see under "Accessories," p. 87.

VI.—THERMO-GENERATORS.

General.—In apparatus for obtaining electricity directly from heat, or obtaining power from heat by means of magnetism, there was almost nothing of interest, although some new developments have been made within the last few years, none of which, however, have advanced farther than the laboratory.

The only novelty exhibited was the pyromagnetic motor of Edison. The thermopile seems to be the only converter of this class which has developed to a commercial apparatus, and it appears that this, like the steam engine, has reached a practical limit of development which, at best, leaves it a very inefficient converter of energy. This field, which ranks among the most important in science, is at the same time one of the most undeveloped.

Besides the Edison motor mentioned, a few slightly improved thermopiles constituted all that there was exhibited in this important field.

Chaudron.—J. B. Chaudron (French section, bronze medal) exhibited a thermopile, the chief claims for which are its details of construction. It does not, however, differ greatly from the usual Clamond forms. The elements are tinned iron for the positive pole electrode, and Marcus metal, consisting of two parts antimony and one part zinc, as negative pole electrode. They are arranged in circular layers as usual, with ten couples per layer. The interior cylindrical space is lined with a tube of refractory material; the hot gases from a Bunsen burner pass through a concentric tube perforated with numerous holes which distribute the heat more evenly.

The temperatures are said to be 350° C. (662° F.) on the inside and 80° C. (176°F.) on the outside, making a difference of 270° C. (486° F). The electromotive force of each element as measured by Hospitalier is 0.061 volt; for a battery of 50 elements it was 2.9 volts, internal resistance 0.38 ohms, current on short circuit 7.4 ampères, maximum available energy one-fourth (2.9 by 7.4) = 5.4 watts; consumption of gas 200 liters (7.06 cubic feet) per hour. This corresponds to 1,060 cubic feet of gas per effective horse-power hour, which at the rate of $1.80 per 1,000 cubic feet, is $1.90 per horse-power hour.

Reynier and Fontaine give the cost of a horse-power hour from batteries, from 40 cents to $1.60, so that the cost of power from this thermopile is not much greater than that from some poor batteries. In its application, however, the great convenience of a thermopile as compared to a battery, is of great importance. Besides this the waste heat from the thermopile may be considered as a by-product which can be used for heating in winter and ventilating in summer. They are said to be used chiefly for galvanoplastics, and for laboratories; also in a few cases to charge accumulators.

Clamond-Carpentier.—Carpentier (French section) exhibited a form of Clamond thermopile, which is quite similar in most of its details to the one described above. The metals used are iron or nickel, and an antimony-zinc alloy of equal parts. It is arranged in a convenient form with a burner and refractory lining similar to the one described above. For illustrations of this pile, as well as a description of several others, see La Lumière Électrique, April 14, 1888.

Chalk battery.—In the Edison exhibit was shown a "chalk battery" in which two palladium-faced springs slide on a cylinder of chalk and on its brass mandrel respectively; on revolving the cylinder by hand a current is said to be produced. In the appended description it says "it has as yet been undetermined as to what this is due to." It has been classed here, as its action may possibly be thermal.

Pyromagnetic motor.—In the Edison exhibit was shown a small pyromagnetic motor, which was the only apparatus exhibited for obtaining mechanical energy from heat which was a new departure from the well-known methods. Though not yet a commercial success, it at least represents one of the very few new directions of development in this most important and poorly-developed field.

It is based on the well-known fact that iron loses its magnetic qualities on being heated. A cylindrical iron armature is supported on a shaft to allow it to rotate, as in a dynamo, between the poles of a magnet. Hot gases are passed through this armature so as to heat that portion through which the lines of force pass; these lines are thereby deflected into the adjoining colder portions which are thereby attracted to the magnets and in turn become heated, and so on, giving the armature a continuous, rotary motion. Although the motion is necessarily slow, the force developed may be quite great.

For a history of what has been done in this field prior to Edison's application of this principle, see Franklin Institute Journal, October, 1887.

Pyromagnetic generator.—A similar principle was applied by Edison to a generator of electricity, in which the lines of force in being deflected, passed transversely over a series of wires in which, therefore, a current is produced. The difficulty, however, which was the prime cause of its failure as a commercial generator, was that in order to develop a moderately high electromotive force the rapidity of the heating and cooling was too great to be practicable. The generator was not exhibited.

VII.—WIRES, CABLES, AND CONDUITS.

General.—The exhibits of bare wire were confined almost entirely to the French section, and were in general very creditable, showing fineness of work and results of considerable and apparently success-

ful research to obtain a mechanically strong wire of high conductivity for line wire.

High insulation, water-proof wires were equally well exhibited by France and the United States; in the former the insulation used was almost entirely of soft rubber and gutta-percha, while in the latter it was principally paraffin and rubber compounds.

The cable exhibits were confined to a few large, well-known companies from France and England. The cable industry in France has developed almost entirely during the last ten or fifteen years, before which time their cables were made almost entirely in England.

There were a few insulated wire exhibits from Russia, Japan, and elsewhere, but without particular interest.

Historical.—Among the historical exhibits was a sample of an underground wire laid between Baltimore and Washington in 1844. It consisted simply of a copper wire, about No. 18 B. & S. gauge, covered with an insulating compound and inclosed in a lead tube. It was exhibited by the Western Electric Company.

BARE WIRES.

The exhibit of bare wires of the firm of J. O. Mouchel (French section, gold medal) was undoubtedly the finest of its kind and was particularly interesting on account of the fineness and regularity of their goods, as also on account of the very elaborate researches made by them with different alloys, to obtain great tensile strength combined with good conductivity for lines wires, and to obtain great resistance with small temperature coefficient for resistance coils.

These are probably the oldest wire manufacturers in France, dating as far back as 1709. They employ at present 200 hands (of whom 120 have been there more than ten years) and 450 horse power. Their specialty is fine, delicate work, purity of alloys, length of pieces, and regularity of diameter.

Impurities in copper.—The following table gives the results of their elaborate experiments made in 1884 to study the effects of impurities of small quantities of foreign metals alloyed with copper:

Wires 0.50 millimeter diameter, annealed. Alloys of pure copper with 1 part of the following metals (pure) in 1,000.	Resistance per kilometer in legal ohms at 0° C.	Conductivity.	Elongation. Per cent.	Ultimate tensile strength in kilograms per square millimeter.
Lead	78.21	104.04	36.20	19.09
Molybdenum	78.78	103.28	33.50	21.90
Cobalt	79.17	102.77	38.15	20.62
Silver	79.30	102.60	4.25	29.02
Sulphur	79.31	102.59	37.55	21.51
Gold	79.35	102.54	32.45	20.62
Selenium	79.43	102.44	30.42	27.23
Thallium	79.44	102.42	36.10	21.26
Zinc	79.59	102.22	35.32	27.06

Wires 0.50 millimeter diameter, annealed. Alloys of pure copper with 1 part of the following metals (pure) in 1,000.	Resistance per kilometer in legal ohms at 0° C.	Conductivity.	Elongation. Per cent.	Ultimate tensile strength in kilograms per square millimeter.
Antimony	81.30	100.08	30.00	22.91
Tellurium	81.50	99.84	1.82	41.35
Platinum	81.98	99.25	38.80	20.37
Nickel	82.72	98.37	39.00	20.88
Tungsten	84.08	96.77	36.35	21.51
Tin	84.49	96.31	3.65	32.42
Chromium	85.64	95.01	33.55	22.92
Magnesium	86.29	94.29	3.75	36.54
Aluminium	89.86	90.55	35.20	22.15
Manganese	90.09	90.31	33.75	27.57
Iron	97.65	83.32	32.65	22.05
Arsenic	105.17	77.36	39.10	21.77
Silicon	120.44	67.55	20.65	18.33
Phosphorus	149.84	54.30	31.25	23.42
Bismuth	Unmanageable.			
Cadmium				
Potassium				
Sodium				

Alloys of copper—The different effects of different proportions are seen in the two following striking examples: one tenth of 1 per cent of phosphorus reduces the conductivity of copper to 54.30 per cent, while 5¼ per cent reduces it only to 10.079 per cent. With arsenic one tenth of 1 per cent reduces copper to 77.96 per cent, while 5 per cent reduces it to 5.72 per cent.

Pure copper.—They exhibited also a pure copper wire, the conductivity of which is 104.69 per cent deduced from measurements which were controlled at the Vienna Exposition and certified to by Messrs. Blavier, Stefan, and Discher. This very high conductivity of copper, which is doubtless correct, simply shows that the generally accepted value for pure copper is too low. Next to this exhibit of remarkably high conductivity there was shown, by way of contrast, a similar wire of 0.50 millimeters of remarkably high resistance, made of an alloy of copper and arsenic, having a resistance of 2,335.50 ohms per kilometer, which is equivalent to a conductivity of 3.48 per cent, or about double the resistance of German silver.

Commercial copper.—Their regular copper telegraph wire, annealed, has a conductivity of 102.5 per cent, an elongation of 35 to 38 per cent, and a breaking strain of 20 to 25 kilograms per square millimeter (28,000 to 35,000 pounds per square inch), depending on the degree of annealing. The coefficient of temperature is 0.40 per cent per degree centigrade.

Bronzes.—Their two principal bronzes have 98.5 per cent with 45 kilograms (64,000 pounds per square inch), and 34.6 per cent with 75 to 90 kilograms (107,000 to 128,000 pounds per square inch) as con-

ductivity and breaking strain respectively. These can be wound around a wire of their own diameter without showing any breaks. The former will stand twenty bendings in a vise, and the latter thirty to thirty-five.

Magnesium bronze.—Their experiments with magnesium have given very interesting results, showing great strength combined with good conductivity. The following figures show some of the results:

Conductivity.	Breaking strain.
Per cent.	*Kilograms per square millimeter.*
95.16	51.80
81.60	61.09
63.89	75.17
58.01	81.37
51.43	95.49
50.61	76.47

They find it impracticable to go below 50 per cent conductivity, or above 70 kilograms breaking strain. For exceptionally great spans of line wire they have arrived at 100 to 110 kilograms with a conductivity of 21 per cent. These figures are nearly the same as those of the silicium bronze wire exhibited by Weiller, described below.

Resistance wire.—Their German silver resistance wire has a conductivity of 7.35 to 4.40 per cent. They find that while all known alloys increase in conductivity on being annealed, the German silver will decrease when the proportion of nickel is greater than 10 per cent.

Their new high resistance arsenic alloy, containing 10 per cent of arsenic, has a conductivity of only 3½ per cent and a temperature coefficient of only 0.0258 per cent per degree centigrade (that of German silver being 0.0393 per cent). This alloy is very difficult to work, but in spite of this they exhibited it drawn to the remarkably small diameter of seventeen thousandths of a millimeter, or 0.00067 inch, or about one-tenth as fine as No. 34 American gauge. The resistance of this wire is 2,052 ohms per meter.

Another curiosity which they have made is a coil of telegraph wire in a single piece (without any joints) weighing 660 pounds. This was before electric welding came into use.

Silicium bronze.—Lazare, Weiller & Co. (French section, gold medal) had a fine exhibit of bare wire, chiefly of their patent Silicium bronze, which appears to be their specialty. They claim as advantages for this line wire, over the usual iron or steel wire, that for the same conductivity the weight per mile is several times as small; that, therefore, it is much easier to run; that it diminishes the dimensions and number of poles and insulators; and that, owing to its increased

strength, there is less danger of rupture from wind and snow; also that it is absolutely inoxydizable.

Properties.—The following figures taken from their tables show the most important properties. For long telegraph lines a silicium-bronze telegraph wire of 2 millimeters diameter (0.079 inch, or about No. 12 B. & S. gauge) weighing 28 kilograms per kilometer (100 pounds per mile) has the same resistance as, and can replace, the usual galvanized iron wire 5 millimeters in diameter (0.197 inch, or about No. 4 B. & S. gauge) weighing 155 kilograms per kilometer (550 pounds per mile) and having a resistance of 5.40 ohms per kilometer (8.7 ohms per mile). For telephone lines, a silicium-bronze wire of 1.1 millimeters diameter (0.043 inch, or about No. 17 B. & S.) weighing 8.45 kilograms per kilometer (300 pounds per mile) has the same resistance and can replace a steel wire of 2 millimeters diameter (0.079 inch, or about No. 12 B. & S. gauge) weighing 25 kilograms per kilometer (89 pounds per mile) and having a resistance of 40 ohms per kilometer (64 pounds per mile).

The conductivity and tensile strength may be varied at pleasure, for different purposes; as one quality increases, the other diminishes. The following figures, showing the properties, are taken from their tables, and are here reduced to our units:

Size of silicium-bronze wire 1.5 millimeters, or 0.059 inch, or No. 15 B. and S. gauge.

	Weight in kilograms per kilometer.	Weight in pounds per mile.	Tensile strength in kilograms per square millimeter.	Tensile strength in pounds per square inch.	Resistance in ohms per kilometer.	Resistance in ohms per mile.	Conductivity in per cent as compared with copper (having 20.57 ohms per kilometer per 1 millimeter diameter).
For long distance telegraph lines.	15.75	56	45	64,000	9.45	15.2	97
For long span telegraph lines ...	15.75	56	56	79,600	11.42	18.4	80
For telephone lines.....	15.75	56	75	106,600	28.8	46.4	32
For telephone line, new type...	15.75	56	80	113,800	21.77	35.0	42
For long span telephone lines ...	15.75	56	112.5	160,000	43.53	70.0	20

Bi-metallic.—Charles Martin & Co. (French section, bronze medal) exhibited a line wire called "bi-metallic," consisting of a core of steel, and a thick solid layer of copper around it and united to it. The proportions of copper and steel are about half and half. It is made not only for telegraph and telephone lines but also for the transmission of power and light, as well as for electric bell circuits. Pure copper wire would be best for lines were it not for the high price, and the fact that, as it is so soft, it is apt to tear when in long spans, or to elongate by its own weight, thereby diminishing its cross section and increasing its resistance. The object of this bi-metallic wire is to combine great tensile strength with good conductivity, small weight, and cheapness.

The advantages claimed over the phosphor and silicium bronze wires are, that the latter are brittle and will not stand bending or twisting, and that in course of time they become granular or crystalline, and that they are expensive. The object of the bi-metallic wire is to combine the good conductivity of copper with the tensile strength of steel, and at the same time use the copper sheath to protect the steel from the action of the air and water.

The process is not described, being apparently a secret. The two metals are firmly united, as though they were welded.

The weight and diameter are evidently less than that of a steel wire of the same conductivity would be, and it is claimed to resist a greater tensile stress than copper wire. It is claimed to resist perfectly bending and torsion, and that it is quite flexible and elastic. The selling price, for 1 millimeter diameter and over, is given as 150 francs per 100 kilograms, which is equal to about 13 cents per pound.

There is a disadvantage in its use, however, namely, that if the steel should be exposed anywhere, the action of moisture will be to destroy the steel at that place much more rapidly than if it were not covered with copper, because the steel and copper form a short-circuited electric couple the action of which is to decompose the iron and to clean the copper. In galvanized iron wire this electrical and chemical action is just the reverse, as it keeps the iron clean at the expense of the zinc.

Copper-covered iron wire was made in the United States more than a dozen years ago, and for the same object. It was made by electroplating the iron wire with a thick coating of copper. But it was found that the iron wire appeared to absorb in its pores some of the liquid of the bath, which in time destroyed the iron completely by the action described above. All the lines run had to be replaced, and the extensive wire works had to be abandoned. It is presumed, therefore, that the process of Martin is not the same. In one specimen in Martin's exhibit, the steel was 1½ inches in diameter, and the copper three-eighths of an inch thick.

Properties.—The following figures give the results of some tests of the Martin bi-metallic wire. They were made at the Laboratoire Centrale d'Électricité of the Société Internationale des Électriciens: External diameter, 3 millimeters, or between Nos. 8 and 9 B. & S. gauge. Ultimate tensile strength, 388 kilograms, or 55 kilograms per square millimeter; or 78,000 pounds per square inch. (That of copper is about 26 kilograms per square millimeter, or 37,000 pounds per square inch.) Elongation, 28 per cent. Number of times it could be bent through a right angle alternately in opposite directions when held in a vise, twenty to twenty-four. Resistance per kilometer at 14° C., 3.91 ohms, or 6.3 ohms per mile. (That of copper wire of the same diameter is 2.35 ohms per kilometer, or 3.96 ohms per mile. That of an iron wire of the same diameter is 14.05 ohms per kilometer, or 22.6 ohms per mile.)

From these figures the following deductions may be made: Its conductivity is 60 per cent of that of copper, and 360 per cent of that of iron wire of the same diameter. The size of a copper and iron wire of the same resistance would be 2.33 and 5.7 millimeters, or about Nos. 11 and 3 B. & S. gauge, respectively. The weight of the bi-metallic wire is given as 62.5 kilograms per kilometer, or 222 pounds per mile. That of the iron wire would be about 200 kilograms per kilometer, or 700 pounds per mile. For the same weight of wire on the poles, the number of lines of the same resistance could therefore be tripled, as compared with iron wire. Or, for the same weight as the iron wire, the size of the bi-metallic wire would be 5.4 millimeters (between Nos. 3 and 4) and its conductivity increased 3.2 times.

Another test made by the same parties gave the following results: Diameter 1.29 millimeters, or No. 16 B. & S. gauge. Ultimate breaking tensile strain, 84.5 kilograms, or 65 kilograms per square millimeter, or 92,000 pounds per square inch. Number of times it could be bent backward and forward over a bar 10 millimeters (0.4 inch) diameter, fifty to sixty. Resistance, 19.61 ohms per kilometer, or 31.6 ohms per mile. Resistance as compared with copper wire of the same diameter, 66 per cent.

INSULATED WIRES.

Wood insulation.—Fortin-Hermann (French section, gold medal) exhibited an insulated wire, made of a bare copper wire, on which are threaded small, short wooden beads, quite close to one another, the whole being afterwards covered with a lead pipe. It is, therefore, quite similar to an insulated wire made in the United States some six or eight years ago, in which the beads were of porcelain, instead of wood. The porcelain had the advantage that the beads could be made large and have numerous holes, so as to contain a number of wires in the same lead pipe and insulated from one another. In the case of the Fortin-Hermann multiple-wire cables, each wire is first covered with its beads, and these are afterwards bunched and covered with lead, making, however, a rather bulky cable.

The claims are that it is cheap, that the insulation is very high, and that the specific inductive capacity of the wooden beads is much less than that of porcelain, and that therefore the static capacity is very low, being for underground wires even lower than in aërial lines, and as the air inclosed in the lead remains unchanged the insulation and capacity remain unchanged. It is used largely in Paris for underground telegraph and telephone lines, and has given very good results, particularly for telephone lines. The following data (reduced to miles) was given:

Insulation, per mile	megohms	900 to 6,200
Conductivity, per mile	ohms	10.3 to 18.8
Capacity, per mile	microfarad	.068 to .060

Patterson cables.—The Patterson cables, included in the exhibits of the Western Electric Company (United States section, gold medal, for collective exhibit) was, besides the Okonite exhibit, the only United States exhibit of cables containing many small conductors. They consist of groups of conductors, each covered with two or more windings of cotton or jute, or both, saturated with paraffine, and protected by a pipe made of some composition resembling a lead alloy. This composition is said to withstand the action of the water and gases underground, where lead would be destroyed. It is harder and tougher than lead, without being any less flexible. The space between the conductors and the pipe is filled with hot aërated paraffine, free from any oil, and introduced under pressure, together with carbonic acid gas (CO_2). The almost invisible globules of gas, scattered uniformly through the mass of paraffine, renders it elastic, so that the natural shrinkage of the paraffin in cooling is compensated for by the expansion of these globules, thus preventing the formation of cracks and longitudinal fissures through which water would penetrate indefinitely in case of a break in the pipe. Any flaw or leaking joint in the pipe is detected by the process of filling under pressure. The core may be made in lengths of 1,500 feet and the pipe in lengths of 80 to 140 feet. Another function of the occluded gas is to diminish the specific inductive capacity of the paraffine; it is claimed to diminish it 15 per cent below that of pure solid paraffine, and this, they claim, enables them to use smaller conductors than if gutta-percha or rubber were used. This diminished size is claimed to prevent, to a large extent, troubles from "cross talk," due to the condenser action in the neighboring wires.

The current which leaks through the insulation of a cable has a tendency to produce chemical changes if any liquids are present. High insulation therefore diminishes this action by reducing the injurious current, besides economizing energy. The paraffin used contains no oil which might have traces of acids or alkalies. Their cables vary from one-quarter of an inch to 2 inches in diameter and contain from one to two hundred conductors, in lengths up to 8 miles, and are used for telephone, telegraph, and electric-light service. Some have the conductors twisted in pairs for metallic circuits.

From November, 1881, to June, 1889, they have made cables containing 36,927 miles of conductors, of which 22,313 are underground and of which 36,126 are for telephone, 681 for telegraph, and 120 for electric lights.

Okonite.—The Okonite Company's (United States section, gold medal) insulated wire is too well-known to require description here. No technical data could be obtained from the company. The material, okonite, is reported to be a mixture of India rubber and mineral hydrocarbons. It appears to be placed around the wire in

the form of a band with a longitudinal seam, and adheres to the wire very tenaciously.

An expert test made for the jury showed an insulation resistance of 6,800 megohms per kilometer at 8° C. (4,200 megohms per mile), and a capacity of 0.36 microfarads per kilometer (0.58 per mile).

Cobb.—The Cobb Vulcanite Wire Company (United States section, gold medal) exhibited electric light wire insulated with a moderately hard but pliable vulcanized rubber tube, and with or without a lead armor. This tube is made of rubber, the vulcanization of which is stopped before the rubber becomes as hard as the ordinary hard rubber, thus giving a material, the insulating properties of which are like those of hard rubber, and having the additional property of being pliable, so that it may be bent to a moderately small circle without injury to the insulation. The tubing is first made of soft rubber mixed with sulphur; by means of special machinery a seamless lead pipe is made around this soft tubing; it is then vulcanized under pressure by compressing the air in the tube, after which the stranded copper wire is threaded through lengths of about 200 feet of this tube, by means of a long steel needle, which operation is done quite rapidly by means of special machinery. The insulation is remarkably high, averaging for a No. 4 or 5 wire cable, between 10,000 and 20,000 megohms per mile, and sometimes even exceeding 30,000. This is probably in part due to the fact that the tube fits the wire loosely and that it is therefore insulated to a great extent by the air between the wire and its insulating tube. This wire has been used in New York and Chicago for underground circuits.

CABLES.

M. Menier (French section, gold medal), one of the principal and oldest French manufacturers (founded 1850), had a very fine exhibit of insulated wires and cables chiefly of rubber and gutta-percha insulation. This firm is one of the principal ones furnishing wires and cables to the French Government (telegraph and war departments). The factory covers 5 acres of ground, employs 400 men, and 1,000 horse power, using about 300 tons of crude rubber and gutta-percha; their business, including rubber goods, amounting to about $800,000 a year.

They exhibited a piece of their river cable laid for the Government, between Havre and Honfleur (on the opposite sides of the mouth of the Seine), 8½ miles long. It was laid in 1877 and is still in good condition. It consists of five wires insulated with gutta-percha, and protected with jute and a double armor of galvanized iron wire.

The underground electric-light cables, which they have made for Paris and other cities, consist of tinned copper covered with three layers of vulcanized rubber, and covered with lead 2½ millimeters

(one-tenth of an inch) thick. They claim to be the inventors of the double concentric cables.

Other creditable exhibits of cables were those of the India Rubber and Gutta Percha Company (French section, gold medal) and Fowler & Co. (English section, gold medal).

Henley's Telegraph Works Company (English section, silver medal) exhibited samples of a large number of cables made and laid by them. Some of them were of interest historically. The earliest were: A single conductor cable laid at Ceylon in 1857, 30 miles, weight 66 tons; another in Egypt, in 1857, three wires, 9 miles, and 20 tons; another in Tasmania, 1858, 240 miles, weight 408 tons. They were all of the well-known construction, with a galvanized iron wire armor, covered with a protecting compound.

The Commercial Cable Company of New York, showed a model of a cable in which the armor was made of short steel ferrules, the ends of which were made to fit into one another, the joints being rendered air-tight and elastic by means of thick round rubber rings. The object is to protect it from danger from crushing by ice. The crushing strain is 25 tons.

MISCELLANEOUS.

UNDERGROUND WIRES OF PARIS.

These cables are composed of wires of seven strands twisted together and covered with two layers of gutta-percha, alternating with two layers of Chatterton compound. The cables are formed of 3, 5, 7, or 14 of these stranded wires bunched together, spun over with tarred cotton and covered with three layers, the first of tarred jute, the second of cotton tape impregnated with Norway pitch, and the third of tarred cotton tape wound in the opposite direction to the preceding layer. The diameter of the wire used is from 0.5 to 0.7 millimeter (about No. 24 to 21 B. & S. gauge). The seven wires twisted together and covered as described above, are from 3.5 to 5 millimeters (equal to 0.137 to 0.197 inch). The copper has a conductivity of at least 90 per cent that of pure copper; the resistance is not greater than 20.57 ohms per kilometer (equal to 33 ohms per mile), per square millimeter cross section at 0° C. Those most frequently used have the same resistance as iron wire of 4 and 5 millimeters (0.157 and 0.197 inch, or about No. 6 and 4 B. & S. gauge); that is, about 16 to 9.7 ohms per mile. For these the insulation is over 370 megohms per mile at 24° C. (75° F.) and the capacity is less than 0.48 to 0.40 microfarad.

Some others are covered with lead in place of the three layers of of cotton and tape. These are used in the sewers or tunnels, being merely hung on hooks, while those without lead are put into cast-iron tubes in trenches.

For long underground lines the cables are made like the preceding and are generally of three conductors, of which two correspond to an iron wire of 4 millimeters and the other to one of 5. These are placed in cast-iron tubes in trenches. Sometimes, when there is only one cable, it is covered with an armor of iron wire and simply buried. The Société des Téléphones, Menier, India Rubber and Gutta-Percha and Telegraph Works Company (Paris), all three furnish underground wires for the telegraph department of the city of Paris. For electric light underground cables vulcanized rubber is generally used in place of gutta-percha.

French submarine cables.—The conductor of the submarine cables is made of seven strands of copper wire. This is covered with a layer of Chatterton compound and then with three layers of gutta-percha alternating with two of Chatterton compound. This is covered with two layers of jute wound in opposite directions, over which is then placed the armor of iron wire. For deep-sea cables this armor of iron wire is made of small-sized wires, while for shore ends it is made of large wires. For deep-sea cables the armor is galvanized iron, while for shore ends it is an extra fine quality of iron wire known as "Best-Best" quality. This armor is covered with three layers of bituminous compounds and two of tarred linen wound spirally around it.

The submarine cables used by France are almost exclusively made by the large English companies, namely: The Indian Rubber, Gutta-Percha and Telegraph Works Company, the Telegraph Construction and Maintenance Company, and the firm of Siemens Brothers.

Cable making machine.—The administration of telegraphs of France exhibited a small model of the machines used by them at their factory for making cables. The bundle of insulated wires which are to constitute the cable are drawn slowly through a series of tubes in line with each other. Between the end of each tube and the beginning of the next, a layer of the covering material, be it insulation or armor, is wound around the cable from bobbins secured on a revolving disk concentric with these tubes. As the cable passes through, these coverings are thereby wound around it spirally and in alternately opposite directions. It also passes through tanks containing the liquid coating material and finally through a jet of cold water.

Galvanized wire for the French Government.—The following extract from the "specifications for galvanized wire" for the French Government, 1879, shows the requirements made and the tests to which the wire is subjected.

The iron must be reduced and refined entirely with charcoal, and must be free from scale and other faults. It must be galvanized with pure zinc. Wires of 5, 4, 3, and 1 millimeters in diameter must be able to stand a tension of 650, 440, 250, and 30 kilograms,

respectively, with an elongation of not more than 6 per cent. It must resist being wound on a cylinder (size not given) and subjected to a tension of 500, 350, 200, and 22 kilograms, respectively. The wire must resist being secured in a vise and being bent alternately forward and backward through a sharp right angle each way, 3, 4, 5, and 8 times, respectively. It must stand four successive immersions of one minute each in a solution of copper sulphate (1 to 5 parts of water) without being stained. The three larger sizes must stand being wound over a cylinder of 1 centimeter in diameter, and the smaller one over a cylinder of 3 millimeters without detaching the zinc; but the wire will not be held strictly to this test. The wire must be made in France.

In the specifications for 1889 the same conditions were imposed with the following additional requirements: The resistance at 0° C. reduced to a wire of 1 millimeter diameter must not be greater than 156 ohms per kilometer (or about 250 ohms per mile for a No. 18 wire).

Testing.—For testing cables and joints roughly during their manufacture, it appears that the so-called plate or influence machines (Holtz, Wimshurst, Carré, etc.), developing very high tension electricity, are coming into use largely in France. They seem to afford a ready, cheap, and effective means to find whether the cable or joint is good or bad, without, however, enabling the insulation resistance to be measured thereby.

Splices.—The Western Electric Company exhibited some splices of multiple wire Patterson cables, which were said by some French experts to be the finest they had seen. One was of 50 pairs, and others of 125 and 100 wires. The individual splices were distributed spirally over a short length of the cable and afterwards covered with a short piece of lead pipe only slightly larger than the other. They exhibited also some good but somewhat complicated splices for electric light wire cables.

Couplings.—For couplings for splicing wires, see under "Accessories," p. 86.

CONDUITS.

The exhibits of conduits were so few that it may almost be said that this branch was not represented at all. There was only one exhibit in the French section and two in the United States. It is all the more strange that this should be so, because in Europe more than anywhere else underground wires are used.

The explanation is probably that it is considered there such a simple matter to lay well insulated cables in the ground directly, or in troughs of wood or concrete, or in sewers, that there is nothing about it to exhibit. The sidewalks in Paris and many other European cities belong to the streets and not to property owners, and they may therefore be used for such conduits, which overcomes some

difficulties, especiallly in Paris where the surface covering is generally pitch or asphalt, which therefore keeps the ground below quite dry.

Another reason why it is less difficult there, is that they rarely use the high potential circuits so common in our arc-light distribution, and lately also in our alternating-current distribution.

Another reason why it is apparently receiving less attention is that there is so little electric-light distribution there, as compared to our cities, that there is no such need for complete and flexible systems.

Postel-Vinay.—The system exhibited by Postel-Vinay (French section) was of special interest to Americans as it differed so radically from our ususal systems. Instead of using expensive insulating coverings of wires which appear to cause so much trouble here, they use bare wires in the conduits and support them on insulators. The wires for great currents are in the form of a twisted cable, and are supported about every 7 feet in cast-iron supports which are secured to the iron cross pieces through the medium of strong porcelain insulators to which they are cemented with sulphur.

The conduits are made of concrete having the iron cross pieces firmly imbedded in their sides. The conduits are covered with slabs of concrete or flat stones the tops of which are only a few inches below the sidewalk. In crossing streets they tunnel underneath the sewers if necessary. An advantage of such a system is that house connections are readily made, and that the capacity of the wires may readily be increased at any subsequent time by merely laying another wire over the other, in the same supports. A good illustration of this system, as well as of other details of a system installed in Paris, will be found in La Lumière électrique June 29, 1889, p. 604.

The Consolidated Telegraph and Electrical Subway Company (United States section, silver medal) exhibited charts and models of their systems in New York City, all of which are familiar to American readers.

The American Indurated Fiber Company (United States section) exhibited samples of their pipes for underground circuits. They are proposed as a substitute for iron and creosoted wooden tubes which have been used largely. In a descriptive circular they make the following statements: "This pipe is made by a patented process from long wood fibers, separated, washed free from all saps and gums, molded while in a pulpy state into the requisite size and shape, and then subjected to great hydraulic pressure. It is then treated and hardened by a chemical process, which renders it strong, hard, and impervious to acids and moisture, absolutely waterproof, proof against decay or corrosion, and practically indestructible. The pipe is supplied in lengths of 5 feet with sleeve couplings, bearing standard pipe thread, so cut that the ends 'butt'

in coupling, thus preventing any catch or pocket at the joints. Each length is carefully reamed out to a uniform diameter. The weight of the pipe is one-fifth that of iron, and it is therefore more economically handled. The tensile strength of the pipe is about 11,000 pounds to the square inch, and it withstands all ordinary internal pressures. The pipe will resist over 200° of heat, and will stand more frost than iron pipe."

VIII.—APPLICATIONS OF ELECTRICITY IN MEDICINE AND SURGERY.

General.—The apparatus for the application of electricity in medicine and surgery belongs more properly to the department of medicine and surgery, rather than to that of electricity. No attempt is therefore made here to give either a full summary, or a complete description of the exhibits in this branch, nor to describe them from a medical point of view. The following notes are limited to a mere mention of some apparatus which chanced to come to the notice of the writer, and is treated from the point of view of an electrician merely.

It was a satisfaction to notice from the exhibits, that the use of electricity in this branch appeared to be no longer limited chiefly to the practice of the "quack" doctor, but that it was studied systematically and intelligently, and was fast taking an important place in the intelligent practice of medicine and surgery.

The exhibits in this class were quite numerous, and in a number of cases quite elaborate, the apparatus being very complete and creditably designed for convenience and maintenance. The exhibits were limited almost exclusively to the French section.

Unquestionably the finest exhibit was that of Charles Chardin (French section, silver medal). It was quite large and appeared to be very complete, showing good workmanship, intelligent designing, and in a number of cases considerable ingenuity.

A number of improvements were noticed in batteries for medical and surgical (chiefly cauterizing) purposes, with a view chiefly to reducing the amount of attention, care, cleaning, slopping of the liquid, refilling, etc., and for transportable purposes, to make them as light and small as possible. The more important of them will be found described under "batteries." In quite a number of the exhibits of induction coils for generating the so-called "faradic currents" (which are simply interrupted, high tension, alternating currents of different alternating potentials), it was noticed that the usual rapidly vibrating-hammer interrupter of the primary coil was replaced by a long pendulum-like interrupter, by means of which the interruptions were made quite slowly and regular. An adjustable weight on this pendulum enabled the slowness of the interruptions

to be varied between great limits. In another apparatus these "interruptions" were produced by a clockwork and revolving contact.

There were a number of exhibits of high-tension batteries for direct application, as also induction or influence machines for the application of direct high-tension charges. The exhibit of the electrodes and cauteries of many different forms was particularly large and varied.

Bréguet (French section) exhibited a very complete and convenient electrical apparatus designed by Dr. Vigouroux, containing among other things a series of induction coils of different windings, and convenient means for measuring at any time both the potential and the current strength with the same galvanometer. The same maker also exhibited the apparatus of Professor Hayem for registering on a revolving drum the currents used in therapeutics.

For a short description of a bullet probe and induction balance for locating a bullet in a body, see under "telephony," p. 131.

The advantage offered by electrical illumination was made use of in a number of pieces of apparatus. In some a small electric lamp was arranged for internal illumination of cavities, or with a small hand reflector. In the "photophone," attached to the forehead of the operator, or on a stand, a lens was in front and a reflector in back of the lamp, producing a strong, parallel beam of light, the lamp itself being only a small battery lamp.

Another apparatus of interest, though not new in principle, was the ozone generator exhibited in operation by Huguet (French section). The principle is that of Houzeau, namely, that if two parallel plates having metallic coating on their outside surface be charged and discharged in rapid succession, as when connected to the secondary circuit of an induction coil, ozone will be generated in the air space between the plates. The apparatus exhibited is shown in the adjoining cut, Fig. 61, which explains itself. The three concentric cylinders are of glass, the two inner ones having tin foil on one side, as shown. The air, forced in through the tube, passes between the two electrified plates, where it is partially converted into ozone, which is collected and inhaled by the patient. For an illustrated article on this subject see Revue Internationale de l'Électricité, August 25, 1889, p. 133.

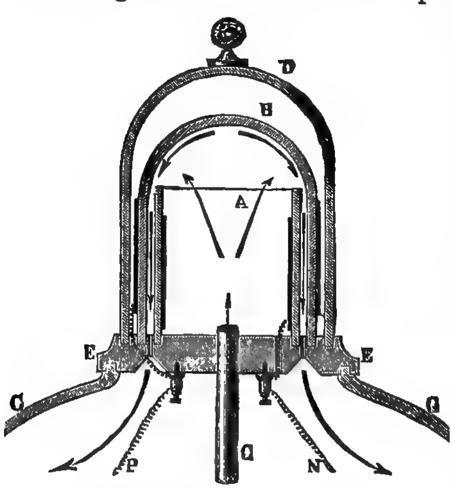


Fig. 61.—Ozone generator; Huguet.

IX.—MISCELLANEOUS EXHIBITS.

LIGHTNING RODS.

Among the half dozen exhibits of lightning rods it was interesting to notice an almost complete change of the general systems, in a diametrically opposite direction, in conformity with the progress of science. In no other class of exhibits was it shown more prominently how the progress of science has, within a short time, almost completely overthrown old and radically wrong ideas which had been adhered to so obstinately for so many years.

In the exhibitions of 1878 and 1881, and doubtless also in subsequent ones, there were exhibits of insulators and holders of various sorts for keeping the lightning rods *insulated* from the building as carefully as possible. In the present exhibition were shown systems and appliances for *connecting* the building electrically as carefully as possible with the lightning rod. The former removes the building as far as possible from the beneficial influence of the lightning rod; the latter, by discharging the house also, protects it as much as possible.

In 1884, when the electrical exhibition building was being fitted with lightning rods on this new and proper system, the "old and experienced" lightning-rod makers (plumbers, we believe) laughed and scoffed at the idea of allowing the rod to be connected to the building and even soldered to the tin roofs. At the present exhibition such makers were, apparently, ashamed to exhibit their former products. In some cases it was noticed also that the intelligent makers used bands and stranded wires to replace the usual solid conductor, in conformity with the recent developments.

In some exhibits, solid, massive, platinum points were used in place of those of brass, platinum plated, on account of the liability of the latter to become fused by a strong discharge, and thereby lose their character of a sharp point, as was shown by samples of actual cases. In another exhibit the maker advocates a lightning-rod tip having a great multitude of points, instead of a few, to facilitate the discharge and distribute it among many points, probably to diminish the liability of fusion of the points.

Milde Fils, & Co. exhibited a complete system showing that they kept pace with all the later developments of science in this branch. They use bands of copper $1\frac{1}{4}$ by $\frac{1}{8}$ inch, tinned on the outside, or, better, iron bands covered with a thick coating of copper which is then tinned, in accordance with the fact lately demonstrated, that the self-induction is less in iron than in copper. Bands are used for this same reason, as also because they can be more readily fastened to the building and bent in conformity with shape of the walls, cornices, etc. The bands are in electrical contact with all the parts of a building, including all water and gas pipes, and have points situated

on the tops of every high part. They are fastened, at intervals of about every foot, by improved clamps, which allows them to expand and contract. The earth plates are made of an open spiral, made of 16 meters of this band, which presents a surface of a square meter. This is put into the well. They prefer to have several grounds for each house.

STEEL MAGNETS.

Meritens (French section) exhibited permanent steel magnets of Clemandot made of steel tempered by compression, a process of his own. Magnets of all shapes were exhibited; among them were horseshoe magnets having the following constants:

Weight of magnet.	Greatest lifting force.	Ratio of lifting force to weight.
Kilos.	*Kilos.*	
24.0	100	4
4.5	50	11
1.7	25	15
1.6	33	20

Another exhibit of permanent magnets, that of Marchal (French section), contained some which had the following constants:

Weight.	Lifting force.	Ratio.
0.15	3	20
0.135	3	22
0.025	1	40

MAGNETIC NICKEL ALLOY.

Joseph Wharton (United States section, honorable mention), exhibited bars of nickel, alloyed with various proportions of tungsten varying from 1 to 6 per cent in different samples. This alloy was magnetic to a considerable degree. At the time of writing no figures had been obtained. The nickel is made from nickeliferous pyrrhotite and is about 99 per cent nickel and 1 per cent impurities, chiefly iron.

NON-MAGNETIC WATCH MOVEMENTS.

We believe it has been sufficiently well demonstrated by experiments that a watch will not be affected by magnetism if the hairspring and the escapement are made of a non-magnetic metal. An iron shield around the watch may protect it in a weak field, but it can not, of course, do so in a powerful field, and it is therefore a protection in a degree only. There were a few exhibits of nonmagnetic hairsprings and escapements, all in the Swiss department. Those of

Paillard, already known in the United States, are made of a palladinum alloy. Patek, Phillippe & Co. exhibited hairsprings of an alloy called "mangor," made by Sandoz; also escapements of "woltine" and "wolfor," made by Weidemann. They all have the same appearance as steel; their composition was not given. Some, if not all of them, have other favorable qualities from a watchmaker's standpoint, besides being non-magnetic.

X.—GENERAL SUPPLIES.

CARBONS.

General.—The exhibits of carbon goods for arc lights, batteries, and microphones, and for many other purposes were almost exclusively in the French section. Most of these French exhibits were very creditable, showing great perfection in the manufacture of such goods. They showed not only the possibility, but also the practicability of molding and shaping the carbon in all possible forms and sizes, and giving to it the properties of great elasticity, density, or porosity, as required for different purposes. Rods were shown, from the size of a hair (presumably for incandescent lamps) up to 3 inches diameter and 3 feet long; plates for microphones as thin as paper; delicate spiral springs having very great elasticity; porous cups for batteries; jars for batteries; tubes of all sizes, and delicately molded pieces of complicated forms for various purposes. All of these were made of molded carbon, as distinguished from cut retort carbon or carbonized vegetable material. No information could be obtained about the processes of manufacture, as these are usually kept secret.

Contrary to our usual custom, the arc-light carbons used in France are very rarely copper-plated. This may be due to the fact that their resistance is sufficiently low not to need a copper coating; but it may also, and more probably, be due to the fact that in their usual systems of distribution the arc lamps are connected in multiple arc, and therefore require some dead resistance in circuit to keep the current steadier.

Another custom different from ours is that for the upper or positive carbon of an arc lamp cored carbons are almost universally used. By a cored carbon is meant one which has a thin rod or core lengthwise through the center, similar to a lead pencil; the carbon of this core, being softer than that around it, burns away sooner than the rest, thereby keeping the crater of the arc always in the same position and preventing the arc from traveling around to different sides of the carbon, which phenomenon in the ordinary carbons is one of the causes of flickering and of a blue light on one side of the lamp. The cored carbons appear to cost from 5 to 10 per cent more than the plain, and in addition to this they burn faster, thus increasing the cost of the light somewhat.

The prices of arc-light carbons seem to be exceedingly high abroad as compared with those in the United States; they are from five to ten times as great.

Exhibits.—Among the chief exhibits and exhibitors were the following:

Edmond E. Carré (French section, silver medal) exhibited among other things very complicated forms, molded and cut, chiefly of fine, delicate workmanship; also long, fine, slender tubes.

In the exhibit of Emile L. Lévy (French section, silver medal) were among other things the following: Arc-light carbons 7 feet long and all diameters; a plate about 3 feet by 18 inches by one-half an inch thick; split hollow cylinders of all sizes for batteries; large. hard crucibles, also one of complicated form for an aluminium process; very thin disks for microphone diaphragms; small balls like shot. for microphones; hair-like threads, probably for incandescent lights; a very elastic spiral 1½ inch diameter made of a round carbon rod of about one-sixteenth of an inch diameter.

In the exhibit of Lacombe & Co. (French section, silver medal), which was chiefly of arc-light carbons, were some very large ones 3 feet long and 3 inches diameter; also 5 feet long and 2 inches diameter; also carbon rods with deep spiral grooves longitudinally, the object of which is probably to keep the arc in the center.

Charles R. Goodwin (French section) exhibited porous cups and battery jars of porous and dense carbon respectively. Also very large blocks and slabs probably for batteries.

August Ballat (French section, honorable mention) was the only exhibitor of "cut" or "retort" carbons, or "French" carbons as they are sometimes called in the United Stases. These carbons are very hard and strong, and are cut from blocks, as distinguished from the others, which are molded from a plastic mass and afterwards hardened. The cut carbons are generally preferred for batteries in which strong acids are used, as they last longer and appear to be more porous, thereby presenting more surface to the liquids. The exhibit was a very fine one, showing pieces cut, turned, and carved into numerous shapes and forms, such as rods for lamps, plates, crucibles, dishes, etc. Among the larger pieces was one 4 feet by 1 inch by 3 inches, and a slab 2 feet by 18 inches by three-fourths of an inch, both without a flaw.

Messrs. Mignon & Rouart (French section, silver medal) exhibited carbons for arc lights covered with a hard, black enamel, which they claim increases the time of burning 25 per cent. This enamel is an insulator and must therefore be taken off whenever contact is to be made with the carbon. The carbons are made of charcoal, of coal tar, pitch, and of lamp black. They are very hard, almost metallic, and are claimed to give very little ash. The published prices are quite high when compared to the usual American carbons.

For instance, the price of a seven-sixteenths inch (11 millimeters) plain carbon is 10.5 cents per foot; cored, 11 cents (or 5 per cent more); enameled, 11.5 cents (or 10 per cent more); cored and enameled, 12.1 cents (or 15 per cent more). The usual price or American carbons, seven-sixteenths of an inch, copper plated, but not cored, is 1 to 1.2 cents per foot, or about one-tenth of the above.

The Compagnie d' Électricité et Hydraulique (Belgian section) also exhibited light carbons for which they claim great whiteness of light and an arc without a flame. Their published prices, for the same size as the above, are 5.9 cents per foot plain and 6.5 cents cored.

A price list from an English company gave 3.4 cents per foot for this size, plain, showing that the American carbons are, as a rule, very much cheaper than those in Europe.

A. de Méritens & Co. (French section), who were the pioneers in electric light-house lighting, exhibited carbons for very large lights, which were made of a number of small rods copper plated and afterwards bunched and secured together to form one large rod. They claim that such carbons will point themselves better while burning, and that the flame will "jump" less than with a homogeneous rod of the same size.

The Solar Carbon and Manufacturing Company, of Pittsburg (Bronze medal), was the only American exhibitor. Their carbons are made from mineral oils. No description could be obtained from the makers.

OTHER SUPPLIES.

HARD RUBBER.

The finest exhibits of hard-rubber and gutta-percha goods in the electrical section were those of the Société Générale des Téléphones, and Casassa Fils et C^{ie}. (silver medal), both in the French section. The latter was particularly interesting, showing excellent workmanship and a wide range of adaptability to different forms and uses. Among them were iron jars and other metallic objects like handles, screws, binding posts, etc., covered with a coating of hard rubber adhering to it with great tenacity.

PORCELAIN AND EARTHENWARE.

Among the chief exhibits of porcelain goods for electrical purposes were Hache, Jullien & Co. and L. Thierre, both in French section (bronze medal). There is little to be described about the exhibits, except to mention the very large assortment of different forms of insulators and insulating knobs, tubes, buttons, etc., both for outdoor and indoor wiring; many of the latter forms were very practically designed for facilitating the wiring. Messrs. Wood-

house & Rawson exhibited a very good form of insulator, shown in Fig. 62, which contains a small quantity of oil to insulate the outside surface of the insulator from the supporting pin.

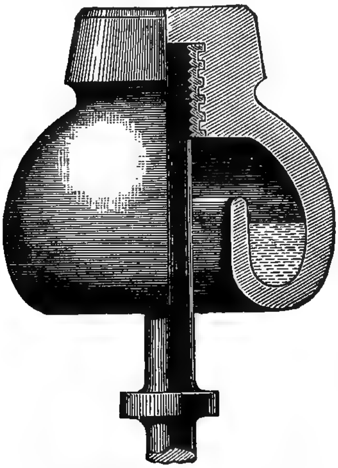


Fig. 62.—Insulator, by Woodhouse & Rawson.

Other novel and ingenious forms of insulators were exhibited by other exhibitors, but they could not be described without illustrations or cuts, neither of which could be obtained.

Fowler, Lancaster & Co. (English section) exhibited a material resembling porcelain, but much better adapted for electrical fixtures. It is hard and strong, and not as brittle as the ordinary porcelain; it can be made with a fine, regular, and sharp screw thread, both inside and outside, which fit together well and smoothly. It can be glazed or colored.

Lallier & Co. (French section, honorable mention) had a creditable exhibit of stone and earthen ware in numerous shapes for different purposes.

FIXTURES.

Among the exhibits of chandeliers, fixtures, globes, shades, etc., were some interesting tulip-shaped shades for incandescent lights, which, from the outside, that is, for transmitted light, had an opalescent appearance with a pink color predominating, while looking at the inside surface, that is, for reflected light, they had the appearance of a bright gilt reflector. They are said to be new, and are known in this country as French shades. Other fixtures, though interesting and numerous, leave nothing to be described.

REPORT

ON

MILITARY AND LIFE-SAVING MATERIAL.

BY

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INTRODUCTORY NOTE.

The writer labored under many disadvantges in procuring information for his report upon the principal war material at the Paris Exposition of 1889. As the United States Government made no exhibit of that character and there were other departments in which he could be of more valuable assistance to his fellow-citizens, he was assigned to duty as juror in Group VIII. This assignment to jury duty occupied all his time from the completion of the installation of exhibits in June, 1889, to the last of September of that year. It was not until the first days of October that he could devote himself with any degree of application to the specialities in the military classes.

From that time until the close of the Exposition the crowds in daily attendance rendered circulation and study of objects very difficult, and at times impossible. Again, the secrecy and jealousy with which all data relating to war material are guarded, both by individual inventors and by Governments, make the search for definite information an arduous task, with little compensation commensurate with the vital energy exerted and expended.

The writer is deeply indebted to the courteous and accomplished Director-General of the Exposition, M. Georges Berger, député, for kindly according him the necessary credentials to make his investigations without unnecessary hindrance.

He is indebted to M. Marc Millas, Consul de France, Secretary of Foreign Sections, for many courtesies and attentions.

He is under deep obligations to Lieut. Malengreau, of the Belgian Artillery, whose guidebook, "L'Artillerie à l'Exposition," was of invaluable service, and to which he is indebted for much valuable information.

To Lieut. Very, U. S. Navy, he is under lasting obligations for much valuable material, and also to Mr. Laurence V. Benét, an engineer of the Hotchkiss Company, who personally conducted him through the splended exhibit of that company and spent much time and labor in collecting information which he kindly placed at the writer's disposal.

To Messrs. Koerner and Wood, of the Hotchkiss Company, Mr. Alfred Evrard, and to many exhibitors, the writer expresses his profound thanks for courtesies and information.

PART I—MILITARY MATERIAL.

CHAPTER I.

GENERAL OBSERVATIONS.

The Military Exposition of 1889 made by the French War and Navy Departments was installed upon the Esplanade des Invalides. It covered about one-sixth of the whole area of that square.

The main building was 150 meters (492.1 feet) long by 22 meters (72.2 feet) wide, and had a second story.

The architecture and arrangement of this building, with its beautiful façade, possessed that artistic merit, beauty, and harmony of decoration in which our French friends have no rivals. (See frontispiece of this volume.)

The approach to the main entrance was a grand gateway built in the style of the middle ages, with towers, ditch, and drawbridge. In one of the towers was installed a colombier or house for the rearing and maintenance of the carrier pigeons designed for military service.

All auxiliary buildings and exhibits were grouped in the vicinity of the main building. A glance at the plans accompanying the report of the Commissioner-General will give a sufficient idea of the arrangement of buildings without further explanations being necessary.

Besides the French Governmental display several individual exhibits were excellent.

The number of exhibitors of war material was much smaller than might have been expected in an age in which one hears constantly of new inventions and gigantic armaments. Some great firms, like Elswick, Whitworth, and Creuzot, were conspicuous by their absence, while others were well represented. Germany, of course, contributed nothing, so the foreign visitor missed the opportunity of comparing the works of Gruson and Krupp with that of the great French manufacturers.

In speaking of the small number of exhibitors the London Engineer, well says:

> If this meant that war material was a matter of decreasing interest, and that swords were at last being turned into plowshares and pruning hooks, there would be great cause for rejoicing; unfortunately we fear the very opposite is the case. The probability of war is such that each nation is developing its engines of war with as much secrecy as circumstances permit, which is a far less healthy condition than one that leads to open, friendly competition in such matters.

We should not have expected the British or German Governments to figure as exhibitors at Paris, but that the French Government itself should show little or nothing contrasts unpleasantly with the display of our own Government war stores, in our "Inventions Exhibitions," some few years since.

The French Government made a magnificent historical and retrospective display of war material, but frankly notified all visitors long before the opening of the Exposition that it did not propose to show anything new of the modern armament. In this, the French merely follow the example of many of their most formidable rivals, and can not be criticised for their desire to keep secret as long as possible the status of their armament.

During the last twenty years great strides have been made in the perfecting of war material. In the great struggle between attack and defense, between gun and armor, both adversaries have wooed and sought alliance with the science of metallurgy, and called upon it for assistance.

The artillerist seeks a lighter and at the same time a more powerful gun, susceptible of giving a greater initial velocity to the projectile, by increasing the length of the bore and using a greater powder charge, and at the same time demanding that the projectile be made of a hard and still harder metal, to enable it to bear the increased shock of impact and to penetrate the increasingly resistant armor without deformation or breaking up.

The naval constructor, in his field, constantly seeks to increase the resistance and efficiency of his armor plates by increasing their thickness to the maximum practical limits, by producing a metal of superior quality, and by the most effective form and distribution of the metal and the employment of harder and harder varieties of steel.

From this struggle there results a demand always for something new in the fabrication of guns, projectiles, and armor plates; a demand for larger and larger ingots of metal, with a corresponding increase in the size and power of the plant and tools necessary to handle and fashion them.

The appliances of the present day must be sufficient to handle these immense masses of metal with economy and with a reasonable certainty of producing the desired result without unnecessary loss. The furnaces for melting these large ingots, the molds for receiving them, the rolling mills for drawing them out, the steam hammers or hydraulic presses for forging or rough fashioning them, the cranes for handling them, the vats and wells for tempering, the annealing furnaces and then the machinery for boring, turning, reaming, rifling, slotting, cutting off, etc., keep increasing in size, strength, and power.

It is to the science of metallurgy that engineers look for their greatest improvements. It would require much space to even indicate the advances this science has made within the last 30 years, and

it would be trenching upon the territory of a colleague if an outline of the progress were attempted in this place.

At the date of the Paris Exposition of 1878 wrought-iron armor plates still maintained their supremacy. The steel plates, cast, hammered, or rolled, were still in their infancy, as they could not be made homogenous or free from internal stresses. This difficulty gave birth to the mixed or compound plates, made of iron and steel combined. The compound plates are still used, but the development of steel plates bids fair to drive the wrought-iron plates and compound plates from the field. For land service the celebrated chilled cast-iron armor of Gruson disputes the field with steel or compound armor.

The physical properties of steel, its hardness, homogeneity, and resistance, go on augmenting.

The French steel works have devoted a great deal of time and money to the theoretical study of steels of different varieties. Every step for each variety of steel has been followed by physical and chemical tests, so that the steel works of to-day are, each, a grand laboratory.

The method of "guessing" is being reduced to a minimum, and that great fraud upon human industry, the so-called "practical man," has been eliminited from the modern French workshop and has been replaced by science and skill, theory and intelligent experience, working side by side, simultaneously, with the same object in view.

It is to this care, guided at every step by theoretical and experimental science, that is due the great success of the modern steel-maker. The greatest discretion is exercised in the selection of ores, in their reduction and treatment, and in all the after operations until the finished product is reached. Every stage is checked, from the mining of the ore to the assembling and testing of the gun or the putting in position of the armor plate.

The scientific labors of Tchernoff, Osmond, and Woerth upon the effects of temperature upon the working of steel have done much to develop this art.

A knowledge of the temperatures at which steel may be forged with impunity without injury to the grain, may be hardened and annealed without determining dangerous interior tensions, is absolutely necessary to secure the best results. The delicate apparatus of the laboratories of science can be applied to these researches, but there is necessary some instrument or means to determine approximately the critical temperatures with sufficient precision to serve as a guide during the several operations. Such a device must be easily and quickly handled, susceptible of continuous usage without injury during the various operations of manipulation, so that these stages of progress may be followed and be executed within the prescribed limits of temperature.

At the works of St.-Jacques, for this purpose, an instrument for measuring the dilatations of the metal is used in the laboratory, while in the forging shop a pyrometric spyglass (*une lunette pyrométrique*) is employed for estimating the temperatures in forging.

This pyrometric spyglass of MM. Mesuré and Nouel has been simplified, so as to make it a pocket instrument, by suppressing the large objective and reducing it to the essential elements, a polarizing prism and an analyzer, with an interposed quartz crystal, and a simple lens for the eyepiece. This simplified apparatus is said to give very satisfactory results in estimating temperatures above 900° C.; below this temperature the results are not so reliable. This inconvenience may be obviated by prolonging the lunette by a tube, blackened interiorly and arranged with a telescope motion for adjustments. If there be an evolution of gas in the furnace under observation the tube may be closed at the end by a glass.

For temperatures above 900° C. the lunette, with a quartz crystal of 11°, gives angular variations quite perceptible and permits the estimation of the temperature with a good deal of accuracy.

It is conceded, for example, that per 100° of the common thermometric scale the angular variations are the following:

6° between 800° and 1,100°
5° between 1,100° and 1,300°
4° between 1,300° and 1,400°
3° above 1,400°

This instrument has been in use at Montluçon for about two years and has become familiar to all the foremen, and by securing identity in all the operations it does much to produce the satisfactory results attained at those works.

The works of St.-Jacques have also adopted and are developing the process of tempering steel masses in baths of melted metal.

This process is claimed to do away, in a great measure, with the variable internal stresses and to produce more uniform results, with less danger of cracking, than in the old processes of tempering in water and oil. It also enables the engineer to use harder varieties of steel in his fabrications, which is a great advantage in the production of armor plates and forged-steel armor-piercing projectiles.

This process is patented by Mr. Alfred Evrard, former director-general of the Chatillon and Commentry Company. It is hoped by this process to produce steel-armor plates, simply cast and tempered in lead, which shall equal in resistance and proportion the best forged-steel plates of the same composition, at half the price.

The first studies were made by Mr. Evrard in 1883, and the experiments made by him in 1883 and 1884 upon steels of different volumes and of different hardnesses had demonstrated:

(1) That the tempering of these steels, at a proper temperature, in a bath of melted lead of four or five times their weight, increased notably the resistance of

these steels to traction and to impact, without sensibly diminishing their elongation, and developed a finer and more regular grain.

(2) That this tempering, provided this designation can be extended to the special molecular action exerted by the metallic bath, avoided, in the hard steels subject to "cracking," this defect, so frequent in pieces of a certain volume when tempered in water or in oil.

The first patent was taken out in France June 30, 1886, and then the company installed a tempering vat with 5,000 kilograms (11,000 pounds) of lead and tempered therein a series of small plates for testing at their polygon in order to study the effects of lead tempering.

A second series of plates made from the same steel was prepared but not tempered, so as to have a comparative test.

The plates were all of the same dimensions, viz:

	Meters.	Inches.
Length	1.500	59.05
Height	0.735	28.93
Width	0.270	10.63

The firing conditions were as follows: Caliber of gun, 95 millimeters (3.74 inches). Projectiles, made of chilled cast iron or of chrome steel, weighing 11.4 kilograms (25.1 pounds). Velocity, 416 meters (1,364.8 f. s.).

The shots were fired at the angles of a lozenge of 2 calibers a side, or 19 centimeters (7.48 inches). The first four rounds were fired at the angles of the lozenge and the following shots were superposed upon the first set.

The nomenclature of the plates (which will be numbered for easy reference) was as follows:

No. 1. Plate of wrought iron of the quality of those furnished the French Navy.
No. 2. Plate composed of chrome steel.
No. 3. Plate composed of chrome steel, tempered in lead.
No. 4. Common compound plate.
No. 5. Common compound plate, tempered in lead.
No. 6. Rolled plate of chrome steel.
No. 7. Rolled plate of chrome steel, tempered in lead.
No. 8. Rolled plate of mild steel.
No. 9. Rolled plate of mild steel, tempered in lead.
No. 10. Cast plate of mild steel.
No. 11. Cast plate of mild steel, tempered in lead.
No. 12. Cast plate of hard steel.
No. 13. Cast plate of hard steel, tempered in lead.

RESULTS OF FIRING.

The plates will be referred to by their numbers as given above.

No. 1. Mean penetration of first four rounds, 132 millimeters (5.2 inches); penetration of subsequent rounds, 198 millimeters (7.79 inches), fissured at seventh round and broke in two at the eighth.

No. 2. At the fifth round a large part of the covering was detached owing to imperfect soldering (this soldering of chrome steel is very difficult to secure); mean penetration, 83 millimeters (3.27 inches).

No. 3. At seventh round part of steel covering fell; mean penetration of first four rounds, 89 millimeters (3.5 inches); the tempering of this plate had taken place under bad conditions).

No. 4. Shattered at fourth round; mean penetration, 95 millimeters (3.74 inches).

No. 5. Shattered at tenth round; penetration, varying from 65 to 72 millimeters (2.56 to 2.83 inches).

No. 6. Shattered at fifth round; penetration, 105 millimeters (4.13 inches).

No. 7. Shattered at sixth round; penetration, 105 millimeters (4.13 inches).

No. 8. Shattered at sixth round; penetration, 112 millimeters (4.41 inches).

No. 9. Shattered at seventh round; penetration, 111 millimeters (4.37 inches).

No. 10. Shattered at fifth round; penetration, 119 millimeters (4.68 inches).

No. 11. Shattered at seventh round; penetration, 113 millimeters (4.45 inches). This plate has then sustained two rounds more after tempering than before.

No. 12. No record given.

No. 13. Shattered at fifth round; penetration, slight, 80 millimeters (3.14 inches), verified only after fifth round.

These experiments indicate the value of lead tempering and show up the quality of mild steel plates simply cast and immersed in a lead bath.

The mild steel plate, cast and tempered in lead, has sustained the firing test as well as the rolled steel plate of similar hardness (compare Nos. 8 and 11).

Here then is a simple and inexpensive operation which apparently gives a cast metal the same qualities as result from forging.

The preliminary trials were so promising that in June, 1887, St. Jacques had installed a tempering vat sufficient for the largest plates, and began operations by tempering the component parts of armored turrets made both of cast steel and compound plates. These parts weighed, each, about 30 tons. No piece failed in tempering, no cracks appeared, and the grain of the metal was found to be what was desired.

Following these trials others were made that year on smaller masses, as follows:

(1) *Projectiles.*—The process was applied to cast-steel shell. The metal was perceptibly improved and there was an increased elongation and resistance to impact.

The comparison with oil-tempered projectiles was as follows:

Lead.—Mean drop of hammer (to rupture shell) 2.6 meters (8.53 feet); elongation, 9 per cent.

Oil.—Mean drop of hammer (to rupture shell) 2.1 meters (6.89 feet); elongation, 6.2 per cent.

The process has been applied to hammered steel projectiles intended to fire against steel or compound plates, viz:

To forty-four chrome steel shells forged, caliber 340 millimeters (13.38 inches), which were tested at Gâvres and are said to have given remarkable results.

To two hundred and ninety bodies of perforating shells, caliber 155 millimeters (6.1 inches), of different profiles.

To one hundred and fifty bodies of 220 millimeters, (8.66 inches) diameter.

To one hundred and fifty bodies of 270 millimeters (10.63 inches) diameter.

These applications showed the value of a first immersion in lead to prevent the spontaneous cracking which is often manifested in the last operation of fabrication.

(2) *Hoops.*—A certain number of hoops were tested with a fall of hammer from a height of 3 meters (9.84 feet). The resistance to impact in the lead-tempered ones was increased from 25 to 30 per cent.

(3) *Gun tubes.*—The effect on gun tubes is equivalent to a tempering in oil followed by a light annealing. It will not probably be of such apparent value for tubes as for other purposes, since the specifications for tube metal demands special qualities.

(4) *Different metals.*—Trials have been made on metals carbureted, silicious, cemented, and refined and containing manganese and chromium. Starting from a carbon yield of 0.40 the effect of the process becomes clearly indicated for forged carbureted metals. For the harder metals the elastic limit is increased from 20 to 30 per cent and the breaking weight from 15 to 20 per cent.

The present condition is as follows:

(1) There exists a process susceptible of forming a useful supplement to the ordinary processes of heavy forging.

(2) It is in current use in one of the great French establishments.

The process of immersion, as practiced by St. Jacques, consists in bringing up to and maintaining at a determined temperature, continually uniform throughout the mass, the large pieces of cast or forged steel which have been heated in the zone of temperature where the transformation of the grain takes place and in which the fissures are produced.

The pieces are previously heated to the proper temperature and then immersed in the liquid bath and there allowed to cool freely.

Metallic baths possess a superior conductivity to oil or water baths, and they avoid the production of that film of vapor which

surrounds the heated mass at the time of immersion and interferes with the transmission of heat in oil and water baths.

SMOKELESS POWDER.

This powder being one of the new inventions about which the greatest secrecy and mystery is rigidly observed, of course nothing was exhibited at the Exposition, and nothing definite could be learned concerning it. Every few weeks one heard of the discovery of a new smokeless or smokeless and noiseless powder. One day it is in France, next in England, then in Germany, another in Roumania, again in Russia or America.

France claims to have solved the problem and to possess a smokeless powder possessing, besides the requisite ballistic qualities, the necessary stability of composition to permit of storage and of withstanding atmospheric variations of temperature and humidity.

All the samples of smokeless powder the writer has seen gave evidence of some volatile ingredient or some organic substance in its composition which did not bespeak a stability requisite for long storage. It may be that, if unaffected by variations of temperature, the use of metallic cartridges would sufficiently protect it from humidity. But organic substances usually undergo changes within themselves, even when protected from exposure to the air.

These powders have their advantages and disadvantages, even assuming that they possess stability of composition and of ballistic qualities.

For machine and rapid-firing guns smokeless powders are next to indispensable for obtaining the full efficiency of their fire.

METAL FOR GUNS.

As this report is not intended to go into gun construction, but is merely descriptive of the main features of the principal exhibits, little will be given except suggestive details sufficient to give the reader a general idea of the subject.

As the Hotchkiss rapid-firing guns are constructed upon the latest conceptions of scientific gun construction and embody all the latest advances in the sciences of metallurgy and gunnery, it will be pertinent and just to select them as samples of the modern art of gun construction.

The metal employed by this company is tempered steel, annealed after tempering.

The prescribed physical qualities, as determined by transverse test specimens, 2.7 inches between measuring points, are as follows:

Minimum limit of elasticity per square inch	pounds	51,500
Tensile limit per square inch	do	94,000
Elongation after rupture	per cent	15

No maximum limits are imposed, and these may be exceeded, but must not in any case fall below the above figures.

As a rule the elastic limit gravitates around 61,000 pounds per square inch, with an elongation of 17 per cent for transverse and 21 per cent for longitudinal tests.

To show the excellence of this metal it may be well to give the Woolwich and French navy requirements for comparison.

Metal for tubes and jackets of French naval guns.

Limit of elasticity, mean, per square inch	pounds..	45,500
Tensile strength, mean, per square inch	do ...	88,200
Variations allowed above and below mean—		
Elastic, per square inch	pounds..	11,400
Tensile, per square inch	do....	20,000
Elongation after rupture	per cent..	14

These must be annealed after tempering.

Woolwich English gun tubes and jackets.

Elastic limits—		
Maximum, per square inch	pounds..	73,200
Minimum, per square inch	do....	56,500
Tensile strength—		
Maximum, per square inch	pounds..	107,500
Minimum, per square inch	do....	81,100
Elongation after rupture	per cent..	10

These are not absolutely required to be annealed after tempering.

The general practice now is to anneal all pieces after tempering, to relieve the intense interior strains set up by the tempering process.

The English require a harder metal than the French. The mean elastic and tensile limits are greater, while the difference between the elastic and tensile limits is smaller and the elongations are less.

The Hotchkiss guns have metal with as high elastic and tensile limits as the English guns, while it has the ductility of the French. This can easily be obtained, since the masses for the Hotchkiss gun are quite small.

The tolerance for inaccuracy of work in finishing shrinkage surfaces is about one one-thousandth of an inch and on such small diameters must be taken into account.

RAPID-FIRING GUNS.

The rapid development of torpedo boats and the great increase in their resistance and speed, due to armor plating, division into compartments by resisting bulkheads, improvements in engines, models, etc., have rendered them formidable enemies to heavily armored vessels of slower movements. It was to counteract this difference of velocity and to afford an adequate protection to the costly iron-clads of to-day that there was placed in their armament a gun which was

not only offensive in its character, but of sufficient defensive value to be able to reach a torpedo boat before it could get within striking distance.

The conditions required that this arm should not only reach the torpedo boat before it got within the dangerous limit, but that it should have sufficient power to penetrate the sides, pass through the bulkheads, and reach and destroy or disable the machinery before the torpedo boat could get near enough for the effective launching of her torpedoes filled with high explosives.

It was this want that gave birth to the rapid-firing gun.

The conditions require that this gun should have—

(1) Rapidity of fire.

(2) Accuracy.

(3) Undisturbed aim.

(4) Facility of maneuver.

(5) Sufficiently powerful projectiles to penetrate not only the wall, but the interior arrangements, and explode inside so as to destroy or disable the machinery.

(6) High velocity of projectile with correspondingly flat trajectory.

(7) Strength and lightness of gun, with lightness and elasticity of mount.

The rapid-firing gun fills these requirements. It possesses the power and accuracy of a small-caliber field gun with greater rapidity of fire and ease of handling, and less weight.

The mitrailleuse possessed the rapidity and accuracy of fire, but not the range and energy of projectile necessary to impede the advance of a torpedo boat.

The rapid-firing guns are not only adapted to naval uses, but to field and garrison service.

RAPID-FIRING GUNS IN FIELD SERVICE.

Their lightness and consequent mobility, their accuracy and range, with their employment of explosive shells, fit them for accompanying cavalry, operating in the front and on the flanks of armies, either as scouting, foraging, or reconnoitering parties.

They can be utilized to repulse attacks of the enemy's cavalry or to silence his artillery. In case of a charge from his cavalry their principal use is to break his lines and throw them into disorder, and if possible compel a retreat.

Ordinary field batteries could silence the enemy's artillery fire, but can not be used so advantageously in repelling a charge.

The objection that the projectiles of rapid-firing guns are too small to destroy an enemy's material is offset by the fact, that with rapidity of fire they could put an enemy's battery *hors de combat*, through his loss of horses and men, more quickly than would a field battery.

The extreme mobility of these guns is a great advantage, in that they would not in the least embarrass the movements of cavalry, even in a rugged country.

These guns may be used with advantage in batteries accompanying infantry. If each battery had a section of these guns they could be employed—

(1) As range finders, since they use explosive shell, with time and percussion fuses.

(2) To protect the battery flanks from sudden infantry attacks.

(3) To protect the battery from cavalry charges, since they can follow the movements of cavalry with ease and at the same time rain upon it a perfect hail of projectiles, and thus enable the battery proper to fire until the last moment before withdrawing, in case of necessity.

(4) To defend narrow defiles, where field guns could not be put in battery on account of the nature of the ground.

(5) To follow grand guards on the lines of advance and repel attacks upon them, at the same time giving warning to the main body.

(6) For mountain service, where batteries could not follow the movement of troops.

RAPID-FIRING GUNS FOR SIEGE AND GARRISON SERVICE.

Their rapidity of fire and small emplacement especially point them out for use in places where the space is small and the number of men limited, such as in a defense of ditches. Mitrailleuses may be used in flanking ditches, but they are powerless to destroy the enemy's devices used in crossing the ditch in a siege. These guns have sufficient power to destroy his blindages.

Rapid-firing guns may also be employed—

(1) In rifle pits, where there is no space for the recoil of ordinary guns or for platforms.

(2) To defend breeches in the parapet against assault.

(3) In the embrasures of heavy guns, as auxiliary armaments and as inexpensive range finders, to find the distance to the target, for guidance in laying the large-caliber guns, without the expenditure of costly ammunition.

(4) In enfilading the approaches to a work.

(5) In street fighting, being easily mounted on roofs or balconies, or for use through windows.

(6) As artillery support to troops operating in narrow streets.

It is not improbable that the rapid-firing gun will supplant the revolving cannon in its field.

DEFENSE AGAINST TORPEDO BOATS.

Rapid-firing guns are undoubtedly a necessity growing out of the late evolution of first-class torpedo boats, with steel shields, armor,

etc, as the torpedo boat is so small that there is small chance of hitting it until it is within 1,000 yards.

The torpedoes are discharged at a minimum distance of about 300 yards from the vessel. With the speed now attained by these boats they are able to pass over the intervening 700 yards in about two minutes; and it is during this short period that the rapid-firing gun must get in its work of destruction, and with a trained gunner it should score six or seven hits in that time.

RIGGS COLLECTION.

This magnificent collection of ancient arms and armor arrested the attention and called forth the highest encomiums of every visitor. Its collection has demanded years of conscientious labor and the outlay of a munificent fortune. Unfortunately Mr. Riggs was unable to prepare his complete catalogue in time for the Exposition. It would take a volume in itself to do justice to the riches of this unique collection. A few only of these valuable historical relics of the past will be mentioned, to feebly indicate the value of a collection which will, day by day, increase in value and interest.

In the middle of the hall was shown a splendid set of armor for knight and horse. It belonged to the Grand Duke Marie Antoine de Colonna, Duke of Polliano and Jagliacozzo, grand constable of the Kingdom of Naples in the sixteenth century. It is engraved in arabesques of flowers and modillions of the Roman emperors, and bears upon every piece the arms of the family Colonna and the baton of constable. It is in an excellent state of preservation.

In a glass case were two half armors of great beauty: (1) a half armor repoussé, chased and damascened in gold and silver. It belonged to Alvarez of Toledo, Duke of Alba, governor of Holland. It was a work of the celebrated artist Giulio Piccimino, and was given to the Duke of Alba by Philip II of Spain. (2) An Italian half armor of the sixteenth century engraved and gilded in imitation of the fabrics of that epoch.

These are followed by many pieces of armor of beautiful workmanship, and a chronologic series of helmets, shields, and bucklers of great interest.

Among the swords are found that of Francis I, of magnificent handicraft, sculptured, engraved, gilded, and inscribed; a German sword of the fifteenth century; a large sword, beginning of the sixteenth century, of the Pope Leo X, and a large number of rapiers and Toledo blades of historic value.

These are supplemented by innumerable pieces of armor, helmets, shields, gauntlets, stirrups, spurs, besides ancient pistols, guns, and daggers.

It is stated on good authority to be the finest single collection in the world.

MISCELLANEOUS.

Of small arms, hunting and sporting arms, metallic cartridges, and all the accessories, little need be said, since they are all, more or less, well-known to the public in the United States, and there was nothing specially novel observed.

The only American exhibitors were the Winchester Arms Company, the Union Metallic Cartridge Company, Colt's Patent Fire Arms Manufacturing Company, and Smith & Wesson, all of whose products are too well known to need description.

The English and French firms made a fine display of portable weapons.

CAST-IRON PROJECTILES.

The French cast-iron projectiles for rapid firing field and heavy guns were the finest ever seen by the writer They were veritable triumphs of the iron molder's art. The castings were smooth, accurate in dimensions and weight, and without blow-holes, cavities, hair lines, or spongy places.

The products of the American projectile founder can not be classed in the same category, if judged by the current deliveries of the past 10 years. The American cast-iron ordnance founder has much to learn from his French brother.

It is true that the French ordnance founder brings to his aid all the skill and knowledge that metallurgical and physical science can produce, while our founders do not incur the expense necessary to command such assistance.

The time was when America led the world in cast-iron castings· it does so no more.

CHAPTER II.

EXHIBIT OF THE FRENCH WAR DEPARTMENT.

The War Department of the French Government made a magnificent display of historic material, but from motives of prudence did not exhibit anything which it deemed that the defense of the country required to be kept secret.

The military exhibit was divided into two distinct categories, viz:

(1) Modern military arts.

(2) Retrospective military arts.

This exhibit was organized and installed by two committees whose officers were as follows: President, Maj. Gen. Coste; vice-president, Capt. de Vaisseau Thierry; reporter, Mr. Gustave Jeanson, chief of the bureau of correspondence in the War Department; secretary, Mr. Gaston Chabert, editor of the War Department.

MODERN MILITARY ARTS.

This category is classified as follows:

I.—Military geography and cartography.
II.—Military telegraphy.
III.—Cavalry.
IV.—Artillery.
V.—Military engineering.
VI.—Aërostation.
VII.—Administrative services. Subsistence and campment.
VIII.—Manufacture of powder.
IX.—Medical and sanitary services of the Army.

I.—Military Geography and Cartography.

This comprises a complete historic collection of maps from the creation of the geographic depot in the War Department in 1688 (established by Louvois, then Minister of War) down to the present time, together with all astronomic and geodetic instruments.

The exhibit is divided into modern exposition and retrospective exposition, each of which is subdivided into instruments and maps.

The maps have been chosen to represent a general history of topography in France from the beginning of the eighteenth century to the present time.

The retrospective exhibit covers all the maps which preceded the publication in 1833 of the first sheet of the large map of France to a scale of 1:80,000.

The modern exhibit includes all the maps which have appeared since that date.

To show the development of this bureau of the War Department it may be cited that, in 1801, the number of engraved maps placed on sale at the depot of this Department was only six; in 1889 there were about two hundred and fifty, comprising more than eighteen hundred sheets.

In connection with this subject it may be well to recall that the old French Academy of Sciences was the first to undertake the geodesic operations necessary to make known the exact form and dimensions of the terrestrial spheroid.

In 1669 Picard undertook for the first time the measurement of a degree of the meridian of Paris. A little later, Dominique Cassini extended this measurement to the whole arc of that meridian which passed through France. Some years after, the French astronomers measured an arc of a meridian in Peru and in Lapland. Still later, Cassini de Thury measured the French meridian, and La Caille went to the Cape of Good Hope to verify the length of a degree of latitude at that place.

In 1790 Delambre and Méchain redetermined and extended the meridian of France to Barcelona in connection with determining a fundamental unit for the metric system. This meridian was prolonged by Biot and Arago to the Balearics shortly afterwards.

The perfection of instruments and the introduction of new methods which were more accurate led the Minister of War in 1869 to order a new measurement of the meridian of France. This measurement is just finished.

The maps and instruments are too numerous to mention within the space allotted to this report, and therefore reference will only be made to the standard map of France to a scale of 1:80,000, in two hundred and seventy-three sheets, called the "Carte de l'État Major" (or staff map). The preparation of this map was directed by royal order August 6, 1817. The geodesic and topographic operations began simultaneously April 1, 1818. The primary and secondary triangulation was completed in 1854, the tertiary in 1863, the topographic surveys in 1866, and the engraving in 1882. The field notes were prepared to a scale of 1:40,000 by the engineers, and the reduction to 1:80,000 by the draughtsmen in the department.

In this remarkable work the engraved surface would cover more than one hundred square meters and represent more than 5,000 years' work of about eight hundred officers or artists, geodetic and topographic engineers, draughtsmen, and engravers. The two hundred and seventy-three sheets seem like the work of one hand, yet it was done by more than sixty-five different artists. It is engraved on copper. This map taken together is 13.2 meters (43.3 feet) long and 12.3 meters (40.35 feet) high.

The map of France scale 1:320,000, in thirty-three sheets, is a reduction to one-fourth of the staff map of 1:80,000. It was engraved and published from 1852 to 1883. It is an excellent map.

II.—Military Telegraphy.

This service comprises the following branches:
(1) Field telegraphy.
(2) Fortress telegraphy.
(3) Light telegraphy.
(4) Military signals.

(1) FIELD TELEGRAPHY.

(*a*) *Station material.*—This comprises the sending and receiving apparatus, the battery, and whatever is necessary for a field station. The transmitting and receiving apparatus belongs to the Morse system. The battery has twelve Leclanché cells. These cells are ebonite cups with the usual zinc and carbon poles. The porous cups are nothing but pieces of sponge which retain the water for solvent purposes. The cells are placed in a partitioned box. The whole apparatus is as light and compact as possible, for easy transport in the field.

(*b*) *Line material.*—This includes all that is required to establish and keep in repair the lines. Two kinds of insulated cables are employed, the field cable and the light cable. The first is stronger and is used for long lines. It is wound on reels in lengths of 1,000 meters (1,090 yards) and is unwound from a cart or wheelbarrow. For short lines or flying posts the light cable is used—length, 500 meters (547 yards). For repairs and maintenance of lines a small supply of naked wires of different diameters are furnished.

The field poles are of bamboo, being both light and stong. Poles in three sections are made, to pass over roadways, etc.; wherever possible existing supports are utilized, and staples are furnished to support the wires. Rubber tubes protect the latter from wearing on the staples. Ladders 3 or 4 meters (10 to 14 feet) long serve as aid in fixing staples. A few forked poles are carried to raise wires and fix them in their supports, etc.

(*c*) *Heavy tools.*—These are hammers, mallets, sledges, and drills or crowbars, used for making the holes for the poles.

(*d*) *Light tools.*—These pertain to the linemen and are carried in a case on the wagon, except when in use on the line. In this event the lineman carries them in a leather case fastened to his belt.

These instruments are the light tools—such as pliers, pinchers, nippers, hand vise, etc., to repair lines and instruments.

(*e*) *Optical instruments.*—The Maugin lens system is employed for field service. The objectives have a diameter of 14 or 24 centimeters (5.51 or 9.45 inches).

(*f*) *Rolling stock.*—This comprises the wheeled vehicles that transport all the materials, tools, apparatus, and personnel for a line. It consists of the pole wagon, four horses, carrying all material and tools, and may have cable reel; of a station wagon, two horses, with a fixed stand for Morse instruments, sounders and battery, and a 14 centimeter optical instrument; of a wire cart, two wheels and one horse, carrying the wire reels and apparatus for testing the lines (sounders, galvanometers, batteries, and keyboards). A light wagon, two horses, serves to transport the personnel; it has also two reels of light cable, for a flying station, and an optical apparatus.

The pole wagon carries the bamboo poles, the insulators, and the extra material.

(*g*) *Organization.*—The service is organized in sections, each composed of three parts. Two are fitted for complete stations and there is a reserve of material, but may be utilized as a station. There are four officers in each section, viz., a chief of section, a sub-chief of section, and two chiefs of station. The first commands the section, the sub-chief the reserve, and the two chiefs of station have charge of the first two sub-stations or station outfits. To these two stations are attached four telegraph operators, two linemen, two foremen, and six artificers.

(2) FORTRESS TELEGRAPHY.

(*a*) *Electric material.*—This consists of permanent lines put up in time of peace, and emergency lines ready for erection and use. The batteries are the same as for the field, except that the number of cells depends on the resistance of the line, and they are of glass instead of ebonite.

(*b*) *Optical material.*—These lenses are larger than the field output, being 30 centimeters (12 inches) to 60 centimeters (24 inches) in diameter. As an emergency precaution some 14 and 24 centimeter lenses are sometimes furnished. These are all of the Maugin system.

(3) FLYING TELEGRAPHY.

This is for cavalry and can be carried on horseback. The Lebiez cell replaces the Leclanché. The wire reel is carried on the back of a man. The electric apparatus is carried by horses. The optical part has a lens of 10 centimeters (3.94 inches). The apparatus is carried in a pair of leather bags on a horse.

A light one-horse two-wheeled vehicle transports the material for four stations and is attached to each brigade.

In each regiment the service of two stations is carried on by three cavalrymen, one a noncommissioned officer. Each station has a telephonic apparatus.

(4) MILITARY SIGNALS.

The infantry signalmen have flags for day correspondence and lanterns for night work. The latter have slides for making the flash signals.

Each battalion has eight signalmen, one a noncommissioned officer, or two men per company. Each company has a pair of flags and a lantern for signal purposes.

III.—CAVALRY.

The display of cavalry equipments was especially varied and most artistically arranged. A great number of reduced models were shown, and all the forms of saddles in use at present or in the past were shown with their accessories. The parts of saddles in process of fabrication were exhibited, as well as a full line of horseshoes, full size, and models of reduced size. The latter were especially noticeable for the exactness of model and beauty of finish.

The equipment and armament of the subdivisions of the cavalry were all brought out in full relief. Gendarmes, gardes républicaines, cuirassiers, dragoons, chasseurs, hussars, chasseurs d'Afrique, spahis, etc.

Photographs and watercolors illustrated this important arm of the service.

Two of the most striking objects in the exhibit were effigies of a cuirrassier and spahi, both mounted. The accuracy of detail was simply wonderful. They were both molded from the living subject.

IV.—ARTILLERY.

The artillery service in France is one of the most important productive services in both the army and the navy.

Its duties and fabrications correspond to those of the following troops in America: The Ordnance Department, the Artillery, and to parts of the Quartermaster's Department, of the Medical Department, of the Subsistence Department, of the Signal Service, and of the Engineer Corps, and to a part of those of various private manufacturers, so far as they relate to military supplies.

It is a ponderous system, but apparently well suited to the bright, quick, painstaking, logical, mathematical mind of the Latin race found in France, where glory and intense love of country are placed above all other attributes.

Its most important duties are:

(1) The machining and complete fabrication of cannon and their projectiles, mountain, field, siege, garrison, and seacoast guns, mortars, and howitzers.

(2) The manufacture and preparation of all ammunition, fireworks, fuses, slow matches, quick matches, etc.

The fabrication of—

(3) Harnesses, saddles, housings, and all horse equipments.

(4) Carriages, engines, machines, armaments. and apparatus of every kind destined for artillery uses.

(5) All small-arms for the whole army and the naval troops.

(6) All headquarters or staff wagons or carriages.

(7) Telegraph carriages and wagons.

(8) Medical wagons, ambulances, etc.

(9) Paymaster and postal wagons for the army.

(10) Quartermaster transport wagons.

(11) Principal types of military powders.

(12) Material for military bridges.

The inspection at private manufactories of the fabrication—

(13) Of projectiles.

(14) Of tubes, jackets, hoops, etc., of steel guns.

(15) Of any war material made of wrought iron, cast iron, or steel.

To provide for the proper performance of these multiple duties the artillery is arranged and divided into the following subdivisions:

(1) The technical section of artillery. This is an auxiliary of the technical committee of artillery.

It is again subdivided into bureaus relating to the several branches of the service, a physical laboratory, with workshop, for making instruments of precision, a shop for the study of materials, harnesses, equipments, etc., a shop for the study of small-arms, a chemical laboratory, and a photographic laboratory.

(2) The gun foundry and factory of Bourges, where all bronze guns and pieces in bronze are made and where nearly all steel guns are machined and assembled.

(3) The Central Pyrotechnic School, at which all kinds of military pyrotechny are studied and fabricated.

(4) The construction and repair shops for material and harness attached to the thirty-two artillery administrations; also the arsenals of construction at Angers, Avignon, Bourges, Douai, Puteaux, Rennes, and Tarbes.

(5) The armories at Chatellerault, St. Etienne, and Tulle.

(6) The inspectors of ordnance and ordnance material at private manufactories.

The experimental studies are confided to a certain number of commissions:

(1) Central commission for the reception of war powders.

(2) Experimental commission of Bourges.

(3) Experimental commission of Calais.

(4) Experimental commission of Versailles.

The historical exhibit of artillery carriages is comprised in the models of reduced scales from the earliest types down to that for 4-pounder rifled gun of model 1858. The types from 1870 to 1881

are shown in the display of service carriages in front of the War Department building.

(1) WORKSHOPS FOR INSTRUMENTS OF PRECISION.

The fabrication of modern guns and projectiles demands the most rigorous care and precision in the various operations of machining, such as boring, reaming, turning, slotting, etc. The variations allowed in the finished dimensions are very small and the specifications are very exacting, but these precautions are absolutely necessary in order to obtain the required accuracy of fire and to insure the strength and stability of the structure. Furthermore, where fabrications are made at many different shops and establishments, it is necessary that they have the same standard gauges and measuring appliances in order that the fabrications may be as nearly identical as possible, or at least come within the prescribed limits based upon a single standard. This can only be done by having all instruments for measuring and verifying the various dimensions emanate from the same source. If this be true with respect to guns and projectiles, it is still more imperative in the manufacture of small-arms and their cartridges, which require the most careful and delicate gauging to secure the interchangeability of the different parts of the mechanism and the uniform action of their ammunition.

It is the office of this central establishment to furnish all the instruments required to verify the dimensions of the various parts used in fabrication, at the several stages of manufacture, and the dimensions of the finished piece, It also furnishes the instruments used in service to inspect the various products from time to time, and to give timely notice, wherever possible, of the degradations due to firing.

In this age of heavy projectiles, large charges of powder, and high pressures, it is especially necessary that the greatest care be taken by frequent inspections to note the changes in the bores of the guns, and the progressive deteriorations they undergo in firing. The wear and enlargements of bores and chambers are made known by star-gauging and comparison with previous measurements; gutta-percha impressions give a record of erosions and the larger fissures, while special optical apparatus must be relied on to detect the finer lines of cracks which pass unperceived by coarser methods, and for the exploration of internal cavities.

(2) INSTRUMENTS FOR MEASURING THE BORES.

Star gauges.—These are used for verifying the interior dimensions of the bores and chambers of guns.

The measuring head is armed with four points, placed in two diameters at right angles to each other. Two points are fixed and serve to support the head in the bore; two are movable and their

spread or diametral length is varied by a double inclined plane to whose longitudinal movement they always respond by a radial movement. The handle or staff is made in convenient lengths, screwed end to end; the number of lengths depending on the length of bore to be measured. The last section, one farthest from the head, is armed with a handle carrying a vernier and adjusting screws.

This is a differential instrument and measures the variations, plus or minus, from a standard diameter established by setting the instrument at zero with the assistance of a ring gauge whose interior diameter corresponds to the required standard. A separate ring gauge and set of points are required for each caliber.

The French star-gauge model, 1876, reads to the one-hundredth of a millimeter (or 0.0004 inch nearly). The inclined planes have a slope of one-twentieth, hence a difference of one one-hundredth of a millimeter in the spread of the points corresponds to a variation of one-tenth millimeter in the position of the inclined plane. The reading is done by means of a vernier.

Two of these gauges were exhibited, one for small and mean calibers and the other with a spiral head for large calibers, starting with 220 millimeters (8.66 inches).

The old model star gauge reads only to one-tenth millimeter. It has no vernier.

A special star gauge has been made for revolving cannon, and as a general rule for very small calibers.

Below this are two star gauges destined for small arms, one for 11 millimeters caliber (0.433 inch), the other for 8 millimeters (0.315 inch). These three gauges read to one one-hundredth millimeter nearly, and by means of two antagonistic springs give a constant pressure, independent of the operator, upon the points. The chambers of small arms have a star gauge also reading to one one-hundredth millimeter.

Alongside these modern instruments was their prototype, the Gribeauval star gauge, with a single inclined plane, constructed about 1765, and modified in 1812.

The usual accessories of ring gauges, points, washers, and wrenches, were exhibited alongside the gauges.

The gauges for verifying the slopes of chambers, projectile seats, breech screw threads, rifling, etc., were shown, as well as a series of small arms gauges.

Electric explorer for bores of guns.—This instrument is intended for examining the walls of the bores of breech-loading guns. It is introduced at the muzzle and the inspector examines the bore from the breech end.

It is a mirror inclined at an angle of 45° to the axis of the bore, and reflects that portion of the wall of the bore opposite to it. A lens placed in front of the mirror enlarges this image for the ob-

server. An incandescent lamp, screened by a hood from the observer, is placed near the mirror and illuminates that portion of the bore to be inspected. The whole is inclosed in a blackened cylinder open on one side just above the mirror. The shaft or handle is made in joints like that of the star gauge to suit the length of bore examined. The two insulated electric conductors are attached to this handle. The size of this lantern is made to correspond with the size of the bores; for 6-inch bores and upwards the same size is employed.

The electric current is furnished by a portable magneto-electric machine made by M. Ducretet, of Paris.

It has a rheostat to proportion the intensity of the current to the resistance of the lamp used. This machine can also be employed for telegraphic work, the explosion of electric primers, etc. It is also useful for examining the interior of shells by employing mirrors and lenses properly arranged.

Full sets of gauges for projectiles were shown, as were also numerous calipers.

The measuring calipers for lengths of 25, 35, 50, 60 centimeters and 1 meter (9.84, 13.78, 19.68, 23.62, and 39.37 inches) read to the one-twentieth of a millimeter (about 0.002 inch).

There were shown three calipers reading to one one-hundredth of a millimeter (about 0.0004 inch); in one a microscope was attached for reading.

For shrinkage surfaces the caliper-points have a constant pressure, and the instrument reads to one one-hundredth of a millimeter (about 0.0004 inch).

A caliper of precision made by Dumoulin-Froment of Paris reads to one one-thousandth of a millimeter (0.00004 inch), and a spherometer giving the half-thousandth of a millimeter (or about 0.00002 of an inch).

(3) APPARATUS FOR STUDYING THE MOTION OF PROJECTILES.

This is an apparatus that is constructed to determine directly the law of the motion of a projectile in the bore of a gun; that is to say, the exact measure of the spaces passed over in terms of a function of the time, in order to deduce from it more rigorously the method of development of the pressures.

The registering projectiles are designed for the direct determination of the law of the motion of the projectile,

The principle of their construction consists in placing in the projectile a mechanism which registers automatically the spaces passed over in functions of the time. This device is a weight sliding along an axial spindle and armed with a tuning fork which can inscribe its vibrations upon one of the faces of the spindle covered for this purpose with lampblack. At the instant the projectile is forcibly

driven forward by the inflammation of the charge, the slider, which is protected from the action of the gases by the walls of the projectile, will, in virtue of its inertia, remain motionless, and will pass over spaces on the spindle relatively equal to those passed over by the projectile in the bore. The projectile is a hollow cylinder, but preserves the weight of the normal projectile. The head is screwed in so that it can be removed to introduce the mechanism; a steel screw plug is placed in the center of the bore for the same purpose. In the axis of the projectile is placed a square spindle with trunnion ends engaging in corresponding cavities in the plug and head. This permits it to turn independently of the projectile and avoids the perturbations due to rifled motion.

A steel slider glides very freely along the spindle and carries a tuning fork whose branches are armed with tracing points to inscribe their vibrations along the surface of the blackened spindle.

Before firing, the slider is placed at the front end of the spindle; a safety pin retains it in this position. At the same time the branches of the tuning fork are kept spread apart by the introduction of a wedge or key fastened to the end of the spindle.

At the instant of firing the safety pin is sheared off and the spindle threads, so to speak, the slider, which rests as it were immovable in space; the separating wedge is torn from the tuning fork which vibrates and the branches trace their sinuous lines on the blackened surfaces, inscribing in their true magnitude the displacement of the projectile.

If the system were reduced to these elements alone it would only give a path of the projectile equal to the free course of the slider. This difficulty is remedied by placing on the opposite face of the spindle a second slider similar to the first, but which only begins to move when the first has completed its course. To effect this action a rod is inserted in the axis of the spindle whose ends are armed with two trunnions placed at right angles to the axis, but turned in opposite directions. These trunnions project through two holes in opposite sides of the straight edge. These holes are cut on opposite sides of the roller or spindle and are large enough to allow displacement of several degrees around the axis of the system. At the instant of firing the forward tenon is in rear of the second slider and retains it in place until the first slider reaches the end of its course, when it strikes the salient trunnion at the rear end of the shot, rotates that system about its axis sufficiently to withdraw the front trunnion into its cavity and release the second slider, leaving it free to move. The second slider at the instant of starting has the same velocity as the projectile at that instant, since until then it was rigidly attached to it, but as the projectile is increasing in its velocity the second slider in its movement along the ruler registers by its tuning fork the law of relative movement.

The line traced by the first slider makes known the velocity of the second at the instant of its departure, and as this velocity is already considerable, and the second slider will require a certain time to pass over its path, it will make known the movement of the projectile over a much greater distance than that which corresponds to the part actually passed over by the second slider.

Precautions are taken to prevent the shock and rebound of the sliders when they bring up at the rear end of the projectile by suitable arrangements.

(4) MISCELLANEOUS.

The photographic laboratory exhibited photographs of various guns and carriages.

A very ingenious device called "*appareil Ricq*" was shown; it is designed to study the pressures developed in firearms from the beginning of the inflammation of the powder to the instant the projectile leaves the bore. It permits the direct registration, continuously, of the law of motion of a small auxiliary projecticle fired at the same time as the normal projectile.

The armories, for small arms, exhibited the finished products of their factories and the parts in various stages of advancement.

The French arms are not finished so elaborately as those demanded by American soldiers. With the excellent milling now done by the improved machines, the extra filing, polishing, etc., is omitted with no detriment to the arm and a saving in cost of manufacture.

The guns exhibited belong to old models or to those in a transition stage, some of which are still retained in service until they can be replaced by better pieces.

The marching headquarters or carriage carries all the maps, archives, desks, etc., for the headquarters staff. One carriage contains all the maps and a table with a copying press. Another a portable printing office and its material. A fourth, for the general or chief of staff, is a kind of coupé and has a table to write orders and consult maps during the march. It also has a case of drawers and file cases for the data relating to several corps d'armée, with locks and keys.

V.—Military Engineering.

This exhibition was chiefly retrospective, but a single model of modern fortification being shown, that of a casemated barracks. A series of models were exhibited to illustrate the classes of work upon which the engineer troops are or have been engaged.

This arm of the service is composed of officers of all grades and five regiments of engineer troops, one of which is a railroad regiment. The special staff of the engineers is charged with the construction and repairs of all permanent works and military buildings,

such as barracks, hospitals, magazines, etc. The artillery construct their own establishments, powder works, etc.

In time of war the engineer troops are divided into five divisions, viz, military miners, saps, bridges, railway, and field works.

They are charged with all the operations connected with these various subjects, and are trained in time of peace, so that they can superintend working parties of other troops in extended operations.

Each company of engineer troops is accompanied by a wagon carrying tools, a wagon carrying tools and small supplies for railway work, a mélenite caisson, and a truck with a half pontoon.

VI.—Military Ballooning.

This exhibit illustrates the history of ballooning and balloon developments. The most important exhibit is the large dirigible balloon "La France," employed by Commandant Renard at the new school of aërostation at Meudon. This balloon has succeeded in returning five times out of seven to its point of departure under the action of its helix and rudder. The maximum velocity was 6.5 meters (21.3 feet) per second.

The balloon is fusiform in shape, about 50.42 meters (about 165 feet) in length, and with a maximum of diameter of 8.4 meters (27.55 feet). Volume about 1,860 cubic meters (65,700 cubic feet).

The car is about 32 meters (105 feet) long, 1.3 meters (4.25 feet) wide (mean), height 1.9 meter (6.23 feet); made of bamboo and steel wire.

	Kilograms.	Pounds.
Weight of car except motor	570	1,256.63
Weight of electric motor	560	1,234.59
Total weight of car without men or ballast	1,130	2.491.23
Weight of balloon and ballonet	369	813.51
Weight of chemise, etc	127	280.00
Total—balloon, ballonet, chemise	500	1,102.31
Total weight without ballast or men	1,630	3,593.50

The electric motor develops 14 horse-power, of which 7 is transmitted to the propeller. The propeller placed in front is 7 meters (22.97 feet) in diameter.

VII.—Administrative Services.

(1) SUBSISTENCE.

Movable ovens.—These ovens are mounted on four-wheeled carriages, and serve to follow close upon the rear of an army in the field, and are "two stories" high, or have two ovens superposed. Each oven can bake forty rations of bread at one "baking," or one hundred and sixty rations for the two bakings per heat, or one thou-

sand six hundred rations for the ten double bakings in 24 hours. Their mobility permits them to keep close to the troops, and diminishes the time of transport of the bread, a great advantage for the quality and preservation of the bread.

Portable ovens.—There are several models of these ovens. One, the best, is the Lespinasse oven, modified by Geneste Herscher & Co., made in five sections, covered with asbestos. This type does not need to be covered with earth each time it is installed. It can bake eighty rations at one time, and is designed to be carried on three pack mules or horses. It is designed for Alpine troops, but is heavy and requires strong mules.

Instead of cylindrical cans for preserved fruits they are made to fit solidly upon the haversack, making them more convenient to carry.

(2) CAMP EQUIPAGE.

This material may be divided into three classes: (*a*) Different systems of tents. (*b*) Sheet iron utensils. (*c*) Officers' mess chest and camp chest.

(A) DIFFERENT SYSTEM OF TENTS.

As a general thing tents are suppressed in European wars, as the troops are cantonned on the inhabitants, or bivouacked in the open air in case of necessity. In cold weather and in sparsely settled communities tents are resorted to for shelter.

Shelter tent.—This is simply a rectangle with buttons and button holes so several sections can be joined together. They are quickly dismounted and can be carried by the soldier.

Conical wall tent.—This is 6 meters (20 feet) in diameter and can shelter ten to twelve men. It originated in Algeria. Its center pole is 3.4 meters (11.1 feet) high and its edges are held by wooden tent pins.

Conical council tent.—This is for councils or courts, or for colonels. It has a center pole and eight radiating rafters which hold the conical top 2.15 meters (7 feet) above the ground at the edges, so a man can stand in any part of the tent.

Regulation officers' tent.—This is a small rectangular A-tent and presents the minimum of weight, volume, and cost price. A man can not stand up in it, nor will it contain a camp bedstead.

The désolu tent is an officer's tent with double walls to inclose a stratum of air and thus keep an even temperature. It contains a hammock for a bed by night and a seat by day. It is a square tent similar to the United States wall tent.

Shelter tent for arms.—This is a narrow elliptical tent with an arm rack notched on both sides to hold the rifles of the soldiers. The rack extends from pole to pole of the tent.

(B) SHEET-IRON CAMP UTENSILS.

There are dishes, cans, and boilers for four men each. They were originally for eight men, but were too inconvenient, and now are adopted for four men. Sometimes, in addition, a man has his own plate besides the large platter in common for four men. The weight and size are reduced as low as possible. Within two years the "individual necessary" has been introduced, it is a small nest of boiler and plate one in the other, with a single cover that answers for either. The object is to permit each man to prepare his food separately.

Coffee is issued in the berry, roasted. It is ground by a mill attached to the cover of a platter or dish. The handle is put inside in carrying. One is issued to each group of fifteen men.

The individual canteen is made of two disks stamped concave and soldered on the middle line around the edge. It holds 1 liter, and is suspended by cords. The cavalry has a canteen set in a drinking cup which hangs in a leather sheath suspended from a shoulder belt.

(C) THE OFFICERS' CAMP CHEST AND MESS CHEST.

Camp chest.—This is as light as possible and contains a change of clothing. It is a little larger than a valise. It is lined inside with light muslin or cloth and the outside is covered with strong cloth painted. It has a copper lock and is held by two straps buckling together above the cover.

Mess chest.—This chest is rectangular like the camp chest, but is larger. Its lid is covered with sheet metal lapping down over the edges to shelter the contents from the rain.

Utensils in chest.—These utensils are called "la batterie de cuisine."

1 lantern.	1 gridiron.	1 kitchen knife.
1 candlestick (flat).	1 pepper box.	1 corkscrew.
1 coffee mill.	1 salt cellar.	5 cups.
3 square boxes.	1 tea kettle.	7 plates.
3 square canteens.	1 frying pan.	6 forks.
1 boiler with double bottom.	1 skimmer.	2 table knives.
	1 ladle.	

There is allowed on an average one mess chest to five officers.

VIII.—MANUFACTURE OF POWDER.

The powder and saltpeter service of France had a separate pavilion to show the method of constructing powder sheds in order to avoid as much as possible the explosives from communicating from one to another in case of accident. The regulation type is to have two working compartments separated from each other by a corridor for transmission of power. A heavy masonry wall 1 meter thick

incloses two sides of each compartment. The other two sides and the roofs are light, so as to oppose as little resistance as possible to the force of explosion.

The compartments are 7 by 7 meters (23 by 23 feet). The buildings are isolated.

The following is a list of the national powder works and establishments belonging to the powder service of France:

Location.	Workmen employed.	Area covered by works.
	Number.	*Hectares.*
1. Angouleme	850	127.
2. Moulin-Blanc, near Brest	625	10.5
3. Pont de Buis (Finistère)	340	37.6
4. Ripault (Indre et Loire)	150	48.0
5. Sevran-Livry (Seine et Oise)	279	115.0
6. Esquerdes (Pas de Calais)	175	34,0
7. Saint Ponce (Ardennes)	34	9.5
8. Vouges (Côte d'Or)	204	34.5
9. Saint Chamas (Bouches du Rhône)	372	58.5
10. Toulouse	90	44.0
11. Saint Médard (near Bordeaux	370	68.0
Total	3,489	586.0

The average annual production of the French powder works is 15,000,000 kilograms or 33,069,000 pounds of explosives of all kinds: black and brown powders, gun cotton, mélenite, smokless powder, etc.

The national refineries of Lille, Bordeaux, and Marseilles furnish the powder works with the sulphur and saltpeter for the fabrication of black and brown powders.

The central laboratory of powders and saltpeters (12 Quai Henri IV at Paris) is the theater of the scientific researches and experiments. It is the headquarters of—

(1) The general inspection of powders and saltpeters.

(2) The commission of fabrication of powders.

(3) The commission on explosive substances.

This last commission has an installation for experiments at the national powder works of Sevran-Livry in addition to its apparatus, etc., at the central laboratory.

INSTRUMENTS.

(1) REGISTERING MANOMETER FOR PRESSURES.

(By MM. SARRAN and VIEILLE.)

This apparatus permits the law of crushing, in functions of the time, of a metallic cylinder under the action of explosive pressures developed in a closed cavity, to be determined.

The apparatus consists of (1) a rotating cylinder driven by an electric motor; (2) a tuning fork, vibrated electrically, tracing automat-

ically on the rotating cylinder a curve at the moment of crushing of the metallic cylinder; (3) a steel projectile furnished at one end with a firing apparatus, and at the other with a crusher manometer whose piston, carrying a pen, inscribes its movement upon the rotating cylinder.

A microscopic reading apparatus is used in connection with the apparatus.

(2) CALORIMETRIC SHELL.

This serves to measure the heat of decomposition of explosives under pressures not exceeding 200 atmospheres (2,947 pounds per square inch). It is covered with platinum to protect it from oxidation. It is also used to determine the heat of combustion in oxygen of explosives of which the composition does not admit of complete combustion through the reciprocal reaction of their elements. The oxygen is forced into the shell and compressed by a pump.

The velocities and pressures in small arms are measured in the same manner as in America. For pressure a housing for the crusher gauge is attached to the military rifle.

The target plate is of chrome steel. The velocities are measured by the Le Boulengé chronograph, all of which are familiar.

The little copper disks for the crusher gauge are 8 millimeters (0.315 inch) in diameter, and 13 millimeters (0.512 inch) long. The pressures range from 1,500 to 2,500 atmospheres (22,100 to 36,000 pounds per square inch), depending on the quickness or slowness of the powders.

(3) HYDRAULIC POWDER PRESS.

This is the Bianchi system for making 100 grains of prismatic powder at the same time. It is used exclusively in France for making brown or chocolate prismatic powders. The press exhibited belonged to the Brazilian Government.

The installation for this 100-grains press is:

(*a*) The press machinery for forming right hexagonal prisms 25 millimeters (0.98 inch) high, 20 millimeters (0.78 inch) for edge of base, with cylindrial axial holes 10 millimeters (0.39 inch) in diameter, mounted on an hydraulic press of forged steel sufficiently strong to support 300 kilograms per square centimeter.

The piston is 35 centimeters (13.78 inches) in diameter, and can exert upon the powder a total pressure of 300,000 kilograms (661,390 pounds).

A cavity is cut around the upper end of the piston, which permits the application of an hydraulic traction upon the head of the piston.

(*b*) An hydraulic accumulator storing up the water under a 100-kilograms (220.46 pounds) pressure and fed by a pump injecting 15 liters per minute.

(*c*) A differential accumulator or multiplier which triples the pressure of the water supplied to it by the first accumulator, so as to finish at 300 kilograms the compression begun at 100 kilograms.

(*d*) A system of stopcocks and valves formed of six stopcocks, of which four are coupled together in sets of two and placed on a cast-iron table so as to be handled by a single workman.

The press machinery comprises one hundred dies or molds, made of very strong bronze, set in a steel block; one hundred lower mandrels made of bronze, with spindles carried by a traveler which rolls on the rails resting on the lower bedplate of the press; one hundred upper mandrels or pistons carried by a plate of cast-iron or steel fastened to the upper bedplate. The loading is done by a copper measure rolling on rails that is filled from a magazine placed beyond the press, and is emptied directly into the dies or molds, which are carried to the rear of the press for that purpose.

The normal speed of molding is 1 pressure in 3 minutes, but it can be done in 2 minutes. The production is 88 kilograms (194 pounds) per hour.

The advantages of this press over mechanical presses are:

(1) Time of compression as long as necessary, which diminishes the pressure on the dies, mandrels, and spindles, and keeps them within suitable limits, while in mechanical presses the shortness of the time subjects them to pressures incompatible with the resistance of the material.

(2) Reduction to a minimum of the displacement of the grain in the mold, which is favorable to the preservation of the material and the regularity of form and texture of the grains; while in mechanical presses the grains are subjected to considerable displacements during compression, which results in energetic friction between the dies and pistons and the powder, which rapidly wear out the material and result in a change of form of the grains.

(3) Greater security, since the apparatus can be stopped at any instant, while with the fly wheels of mechanical presses an instantaneous stoppage is impossible.

The greater regularity and homogeneity of the grains are more favorable to the preparation of the cartridges and to the uniformity of velocities in firing.

M. Bianchi also exhibited two forms of densimeters and an apparatus for studying the combustion of explosives in a vacuum.

IX.—Medical and sanitary services of the army.

The care of the sick and wounded is confided to two services, the field service and the stationary service or permanent hospitals. Very little of the latter was shown. However, three things belonging to this service were exhibited: (1) a tent for the use of contagious patients; (2) a Malbois hospital, which is, however, a little primitive, though excellent for its purpose. The frame is crude, a metallic frame without interstices, upon which are placed high elastic

springs. Stirrups serve to raise the head of the bed. The mattress is excellent, and is enveloped in a strong canvas. A wide band of linoleum isolates the mattress; (3) the Bessoy stove, adapted for tents and hospitals. They have slow combustion and are not very readily moved. They are furnished with numerous tubes, wings, and envelopes to increase their heating surface. The supplies of sterilized cotton, gauze, wadding, and peat wadding of great suppleness, are excellent. These dressings, with their appropriate bandages, are displayed in great profusion. Alongside of them were the new boxes for surgical instruments, which leave little to be desired in either their utility or cleanliness; no leather or silk linings in which swarm microbes, or to catch the dust. The blades and handles are all nickeled. Every possible precaution is taken to save the wounds from extraneous complications.

FIELD MEDICAL SERVICE.

The experiments of the war of 1870, of the Russo-Turkish and the Servo-Bulgarian wars, have taught the surgeons that the quicker the sick and wounded are entirely removed from the field of battle and the army the better; of course with a due regard for the safety of the patients.

The field service has been divided into three distinct but closely correlated branches, viz:

(1) The regimental field service, which depends on the regiment.

(2) The ambulance service, which depends on the division.

(3) The field hospital, which is attached to the army corps.

The evacuation of the field hospitals is effected by sanitary trains and improvised transportation in any vehicles that can be impressed into the service.

(1) The regimental service.

The regimental surgeons are charged with the most perilous part of the service. It is their duty to withdraw the wounded from the field of battle, to apply the antiseptic dressings to the wounds, to reduce fractures, and to send the wounded back in the ambulances. These field ambulances are light, two-wheeled vehicles drawn by one horse, provided with brakes, and can go to any post of assistance. They are painted dark green, and marked with the Geneva Cross. They carry a pair of medicine chests, a pair of reserve baskets, etc. In the medicine chests and baskets are dressings, medicines, and a box of surgical instruments, eight stretchers, and two awnings, a 10-liter canteen, and a 30-liter keg. The two pennants and marine lantern complete the outfit, which, with the empty carriage, weigh 700 kilograms (1,543 pounds).

There is one of these ambulances per battalion of infantry, one per regiment of cavalry, and one per group of batteries of artillery.

The regimental stretcher is the best and most common means of transport of the wounded from the field of battle to the posts of assistance and to the ambulances, as they rarely reach the line of fire.

It is composed of a strong piece of canvas nailed to two handles or bars of light but tough wood, with two iron crossbars jointed to them so as to maintain the rectangle and the four legs. The exploration of wounds with the finger or with instruments at these temporary field stations is interdicted. The antiseptic dressing must be temporary, and the immobility of fractures assured to prevent unnecessary pain in transport. As soon as the diagnostic slip or card is made out, indicating the nature of the wound, its apparent or real gravity, the treatment given, the transport to the ambulance must be the rule.

As for dressings, those treated with corrosive sublimate have the preference, as they stand the action of the air and water for months without changing.

(2) THE AMBULANCE SERVICE.

It is for this service that the Tollet A-tent is designed. The ambulance is only a means of passage, except for those who by reason of serious wounds or dangerous hemorrhages demand immediate attention. Hence, the tents are furnished to give a shelter to permit the surgeons to perform their operations without having recourse to a house which perhaps may be infected. The tent also has the advantage of being able to establish it in the open air near a wood or water course, or wherever it is necessary to establish the ambulance.

The Tollet operating tent is a frame of iron covered with canvas and without pickets. It weighs only 113 kilograms (about 250 pounds), and can be carried on a pack mule and always be at hand at the beginning of an action. It is easily mounted and dismounted without the aid of tools. Its diminsions are 6 by 4 meters (20 by 13 feet). A frame round it at the two ends rests on the ground and forms the plan of the tent. Some arched ribs connected form the frame. The pieces are held by keys and receive the canvas envelope divided into three parts; the one, rectangular, forming the body of the tent, the two others the ends. Air and light come from the door in one face, and a large window in the other face increases the light so necessary in an operating apartment.

The material indispensable to the ambulance service is carried in the carriages mentioned below.

(a) *Surgical carriage.*—Weight, empty, 935 kilograms (2,061 pounds); loaded, 1,550 kilograms (3,417 pounds). It is a complicated structure with a central corridor, two wooden partitions, drawers, cases, etc. In the later models the front part of the corridor has been removed with its partitions, drawers, etc., to make room for baskets which can be taken out through the side doors. They are

light and easily carried by two men. The surgical carriage can stop in the road and the baskets be carried to the operating tent. These baskets and the carriage contain dressings, surgical instruments, necessary medicines, and other material necessary for the service. It is hauled by four horses, is painted gray, has pennants and lanterns. There are two of these carriages per division and two for the general headquarters.

(*b*) *Medical supply carriage.*—This is lighter, drawn by two horses; weighs, empty, 750 kilograms (1,654 pounds), and loaded 1,350 kilograms (2,976 pounds). It carries supplies for the sick, some tools, provisions, and material for the hospital service and pharmacy. There are two carriages per division ambulance, and two for general headquarters.

(*c*) *Reserve supply wagons.*—There are two of these, marked No. 1 and No. 2. Both weigh, empty, 750 kilograms (1,654 pounds). No. 1 loaded weighs 1,162 kilograms (2,561.8 pounds), and carries all the supplies for the pharmacy, and the materials for dressing. No. 2 weighs, loaded, 1,197 kilograms (2,638.9 pounds), and carries the apparatus for fractures, articles for the consumption of the sick, some wine, pennants, stretchers, etc. These carriages enter into the supply train of the general headquarters and of the division.

The duties of the ambulance surgeons are to revive and refresh the wounded; to send immediately to the field hospital those whose wounds are properly dressed; to modify, change, and complete the dressings that are disarranged; to send to the operating tent those whose wounds demand immediate attention, and to retain those who can not be transported. There are two kinds of ambulances, two-wheeled and four-wheeled, for the transport of wounded.

(*d*) *Light ambulance, model of* 1874–'88.—This carries four wounded, two seated by the side of the driver and two lying down. A little rolling carriage receives the feet at the head of the stretcher and may be pushed to the end of the ambulance without shaking the occupants too much. The handles of the stretchers are inserted in the suspending loops by the driver and stretcher-bearers. The wounded are protected from the weather by impermeable curtains. All have receptacles for wine, water, or tea. There are ten of these ambulances attached to the general headquarters, six to each division, three to each brigade.

(*e*) *Omnibus ambulance, model of* 1874–'88.—This carries four lying down on stretchers, one above and one below on each side. The bottom stretchers are inserted by the rolling carriages above mentioned. The four stretchers are hung on one side from loops attached to the walls, on the other from loops on the rods which support the top. If all the wounded can sit up, the stretchers disappear to the aisle and two seats are let down, accomodating twelve wounded, two by the driver. The general headquarters have six of these am-

bulances, six allowed to the division, and three to a brigade of cavalry.

(3) The field hospital.

The surgeons of the field hospitals must follow the same rules as those of the places of first assistance and ambulance service and send forward all who can be transported, retaining only the urgent cases that can not be displaced without danger.

The material of this hospital is considerable. It has not only the ambulances above mentioned, but wagons and carriages obtained by requisition, supplies and provisions that are absolutely necessary, for it must feed, shelter, and furnish beds for the sick and wounded. It is often established in large buildings or farm houses, but frequently must rely on tents. There are two of these tents.

(1) Tollet's B-tent, with iron frame, without tent pins. This is 15 meters (about 50 feet) long by 6 meters (20 feet) wide, weighing 1,050 kilograms (2,315 pounds). It has the same form as the A-tent, but the half-forms are more numerous, and are connected by transoms upon which rest glazed windows. Two large doors at the ends permit circulation and ventilation; the vitiated air escapes by openings at the upper part of the ends, through perforated canvas. A floor may be laid, and in cold weather two Bessons stoves are erected. The ventilation is excellent, which is very desirable. The tent is double interiorly, to avoid extreme temperatures. It is light and airy, a great advantage due to the windows and perforated canvas.

(2) The Mignot-Mahon tent. It is lighter than the above, ellipsoidal in form, is held by iron tent pins, and wooden tent poles sunk deep in the ground. It may be provided with a floor. It is double, like Tollet's tent, but the walls are farther apart, giving a greater air stratum. The doors are on the sides, and at one end of the tent is a low prolongation like a covered corridor sheltering an inodorous pail, masked by a curtain. The tent is light, 500 kilograms (1,100 pounds), and covers 111 square meters. It is poorly ventilated and lighted.

For contagious diseases, Walker's square tent is used. It is provided with poles and tent pins. It is not well adapted to the service. There are no camp bedsteads.

(4) Ambulance trains.

The wounded whom the danger of mortal hemorrhages condemn to absolute rest, the sick affected with contagious diseases whose dissemination in the hospitals of France might cause serious epidemics, are alone retained in the field hospitals. All others are transported to the nearest railway station and forwarded to the permanent hospitals in the interior.

(1) *Permanent hospital trains.*—The train exhibited is that constructed by the Western Railway (Chemin de Fer de l'Ouest). It is

a very comfortable rolling hospital, and is inexpensive, since the cars are used in time of peace for baggage and express cars on passenger trains, and never go out of the system of the company's roads except in time of war. On receipt of the order for mobilization they are sent to the car shops and fitted up for this special service in a few days. From this time they are employed for no other purpose than transporting sick and wounded. The cars are marked on a panel with the Geneva Cross and the inscription, "Train sanitaire No. 1," etc.

They communicate by means of platforms with guard rails. Each car for the sick has eight berths, in sets of two, one above the other. A special trestle resting on the floor supports the handles of the stretcher-beds of which the bottom is formed of crossed webbing. Each bed has a mattress, a bolster, a pillow, two blankets, and two bed covers. The wounded occupant has on a shelf at the head of his cot, a tea pot, a drinking glass, and a spittoon. A small canvas bag holds the articles he may need.

A hospital ticket is placed on a planchette at the head of each. A shelf holds the clothes. The vitiated air escapes by a roof ventilator, and light comes from the side windows by day and from a lamp at night. The heat is furnished by a slow-combustion coal stove.

The beds are not on springs but the car springs are sufficient to preserve the wounded from violent shocks.

The surgical car contains the pharmacy, instruments, linen, and all that is necessary for the needs of the wounded, and is fitted with draws, cases, etc.

The kitchen car is bright with copper ware, range, table, water reservoir, cooking utensils, etc.

Another car carries the provisions, table service, and glassware.

The surgeons have a car also with mattress beds, compartments and office, lavatory, etc.

The train exhibited is intended for twenty-seven cars, of which twenty-one are for the wounded.

(2) *Temporary hospital trains.*—These are improvised from freight cars. The measures are taken in advance, and all the material is prepared and stored ready for use. Metallic plates are screwed to the panels to hold the suspension heads for the springs whose ends bear the traverses for suspending the stretchers. These points are marked in advance. There are twelve stretchers, in two tiers, in each car, six at each end.

RETROSPECTIVE MILITARY ARTS.

The plan adopted by the French committee for this retrospective exposition was a very comprehensive, effective, and happy one. It was to show the soldier himself as he is represented in the drawings, paintings, engravings, and prints of his time. Then, to group

around him the arms, equipments, different parts of his uniform, etc., in fact, everything relating to him and his profession that could be found, together with the flags or colors under which he fought. The result was striking, and such as could only be produced by the artistic Frenchman, with his love of order, harmony, and scenic effect.

The installation was a triumph, and while illustrating the glorious legacy of French arms, and awakening patriotic pride by recalling the celebrated heroes of the past, there was nothing to grate upon the sensibilities or wound the feelings of a foreign visitor.

The history of the navy was already represented by the magnificent naval museum in the Louvre, so familiar to visitors of that historic edifice.

The grand divisions adopted for the historical representation of the army followed the lines of its organization, viz: General staff, infantry, cavalry, artillery, and engineers. Lack of space as well as other reasons demanded that the programme be kept within certain well-defined limits.

The following rules were adopted to guide the commission in its installation:

(1) To take for the point of departure of this history the date 1569, considered as being in France, that of the creation of permanent infantry regiments. To close the retrospective series at 1870.

(2) To admit, in point of pictures or engravings, only the contemporary works of the subjects represented, or at least emanating from eye-witnesses (authentic copies, however, if absolutely necessary, being used to replace the document itself).

(3) To borrow the series of portable arms from the artillery museum, and, for the remainder of the ancient objects, to accept only those of an authenticity very probable.

To attempt to describe this historic display would extend this report far beyond the limits assigned to it. Only a few observations will be hazarded. It must have been seen to be fully appreciated. In the vestibule at the head of the grand stairway of the war department building the first thing that caught the eye and fittingly introduced the spectator to this magnificent collection was a trophy formed of all the flags of France from Louis XIV to 1870, with this inscription upon a modillion:

R. F.
1889.
Aux anciennes Armées Francaises.

There were found the busts and portraits of the great warriors of France, with souvenirs of the great Napoleon. Upon the tables were the histories of all the bodies of troops in the French army from their creation to our time. These regimental and corps histories are of special interest to the French observer, as, in a country where military service is obligatory, every man has his regiment in which he has served, and it is with commendable pride that he turns over

the pages upon which are engrossed the list of campaigns, battles, and history of the regiment, to which he can point, and say with praiseworthy emotion, "that is my regiment."

In the hall dedicated to the general staff was the portrait of the Duke of Choiseul, marshal of France, which deserves mention from the touching eloquence of its simple inscription which was:

Charles de Choiseul, Marquis de Plessis-Plaslin, Maréchal de France; 50 ans de services, 47 batailles et combats, 53 villes soumises, 36 blessures; servit sous Charles IX, Henri III, et Henri IV.

It would require a volume in itself to adequately sketch the contents of the halls devoted to the general staff, infantry, cavalry, artillery, and engineers, with their wealth of ancient arms and uniforms, standards, portraits, souvenirs, etc. The same remark may be applied with equal truth to the halls containing the collections of ancient arms and armor, many of which belong to private individuals.

RIGGS COLLECTION.

Among the individual collections none received or deserved more attention than the magnificent collection of ancient arms and armor of our compatriot Mr. Riggs. This is one of the most valuable and complete collections in the world and should be installed in a museum befitting its inestimable value and importance. Our Government should acquire it at all hazards and at any price. It can never be duplicated. (For description see page 272.)

HISTORY OF THE BELGIAN ARMY SINCE 1830.

This exposition was not organized officially by the Belgian war department. It was projected and organized by a Belgian executive committee. This committee had, however, the assistance of a military commission in preparing a programme whose execution was intrusted to, and admirably carried out by Captain Waldor de Heusch of the Belgian Grenadiers, professor of military art and history in the military school of Brussels.

The exposition comprises two distinct categories:

(1) History of the uniforms, artillery material, armament, and military regulations during the half century following the declaration of the neutrality and independence of Belgium (1830).

(2) The representation of the present types of the army uniforms.

Many specimens of ancient armor, arms, banners, etc., were used to complete the artistic arrangment and display, but were not catalogued as an exhibit.

HISTORY OF THE UNIFORMS, ARTILLERY MATERIAL, ARMAMENTS, AND MILITARY REGULATIONS FROM 1830 TO 1880.

(A) UNIFORMS.

The uniforms of the Belgian army in 1830 are represented by nineteen lithographs drawn by the painter Madou.

The different costumes of the Belgian infantry, 1843. are shown by ten water colors by Dubar.

The uniforms of the Belgian army in 1855 are given in eight lithographs by Payen.

A series of four chromo-lithographs by Hyndrix represents the Belgian uniforms from 1859 to 1864.

These drawings are supplemented and completed by twelve statuettes by Jaquet which give the various types of the Belgian army in 1855.

(B) HISTORY OF ARTILLERY MATERIAL (1830–1880).

This history is represented by models, one-fifth size, of the different guns, howitzers, mortars, carriages, and caissons used in Belgium during the fifty years above indicated. No modern guns are shown.

Belgium was one of the first European countries to adopt steel breech-loading field guns. This gun was a 99-millimeter (3.45 inches) cast-steel breech-loading rifle adopted in 1867. The later siege material is chiefly rifled-steel guns, all breech-loading. The 15 centimeters (5.9 inches) is one of the standard pieces for this service.

The defense of the lower Scheldt is committed to two armored turrets, armed with 24-centimeter (9.45 inches) and 30-centimeter (11.81 inches) guns.

The fortification of the Meuse will be of the most modern type of armored turrets and steel rifles.

(C) ARMAMENT.

These small arms consist of many types of muskets, rifles, carbines, and musketoons, ranging from the flintlock model of 1777 to the modern breech-loading small arm.

History.—The change from flint locks to percussion locks was made in 1841. The change from smoothbores to rifles took place in 1853. The transformation from muzzle-loaders to breechloaders was effected in 1867.

A Belgian military commission is at the present time engaged in experimenting, to determine a suitable magazine arm. The two preliminary series of competition trials, carried on in July and October, 1888, left seven types to be still further tested, from which the selection will probably be made. These are—

1. The Austrian Manlicher.
2. The Belgian Manlicher (a modification of the first).
3. The Nagaut, with rectilinear movement (Belgian).
4. The Nagaut, with combined movement (Belgian).
5. The Caspar-Engh.
6. The Pieper-Manlicher.
7. The Mauser.

The first six have a caliber of 8 millimeters (0.315 inch). The last has a caliber of 7.6 millimeters (0.30 inch). There is little difference in their ballistic properties.

These arms will be submitted to firing trials à outrance with the new powders to fully decide the question of breech mechanism.

The Belgian Government is experimenting on two smokeless powders, one called "paper powder" (poudre de papier) and the other "H. P. powder," giving velocities exceeding 600 meters (1,968.5 feet).

It is said that as soon as a decision is reached the magazine rifle adopted will be manufactured at once, at the rate of 50,000 per year for three years to furnish the 150,000 rifles required.

The Belgian cavalry still retain the lance, and in 1859 the two regiments of cuirassiers were changed to two regiments of lancers.

(D) Military regulations.

A glass case contained the different regulations in force in the Belgian army since 1830. The present artillery regulations were not exhibited, as they contain the range and firing tables.

PRESENT TYPES OF BELGIAN ARMY UNIFORMS.

There are two series of drawings, made by Maj. A. Hubert (retired), exhibited, one series representing mounted troops, the other the foot soldier.

A water color, by Cenni, gives a group of all the Belgian military costumes now used in that service.

The sculptor, A. Mignon, has modeled the different Belgian soldiers in various attitudes, which form not only an artistic but an instructive group.

CHAPTER III.

HOTCHKISS ORDNANCE COMPANY.

This company is well known to American readers. Mr. B. B. Hotchkiss, the founder of the company, was a prominent manufacturer of projectiles and other war material during the civil war in America. His factory was situated in Connecticut. In 1875 he established a factory at St. Denis, one of the suburbs of Paris, for the manufacture of revolving cannon and rapid-firing guns, with all the material and ammunition for the service of these pieces.

The adoption of these arms by the great powers produced a rapid extension of the business of the company. The management of the company was in the hands of Mr. Hotchkiss until his death in 1887. At that date the company was divided into two branches, that for France bearing the title of "Société Anonyme des Anciens Etablissements Hotchkiss et Cie," and the one for England being called the "Hotchkiss Ordnance Company, limited." Both companies are under the active management of Messrs. Favarger, Kœrner & de Latouche, former directors of the parent company.

In 1888 a branch was established in the United States with its office in Washington and its works at Providence, R. I.

The French company employs about six hundred workmen, and can produce six pieces per year of each type of gun made, together with all the accessories necessary for service in the field or on shipboard.

Since its origin the company has delivered about 7,600 guns with their accessories, and 3,000,000 rounds of ammunition.

The general principles and the system of construction of the Hotchkiss guns are, as far as possible, made uniform in all designs with the object of simplifying matters to those who deal with the pieces on service, in use, or repair. On this subject Lieut. E. W. Very, U. S. Navy, writes as follows:

It is to be remarked, in considering the development of calibers, that, whatever may be the excellencies developed in any system under application to a single caliber or a limited gradation of calibers, the measure of superiority of the system itself lies in the capability of its application without modification to the complete range of calibers within the scope of the class of artillery. If, for example, any given type of gun be adopted, and it be found necessary to modify the details of the breech mechanism or the type of mount as the calibers of the gun increase or diminish, the result is as unsatisfactory as if a different system were adopted with each caliber,

and it is beyond doubt one of the first requirements of an efficient type of service artillery that throughout its calibers all its details should be similar.

This point of superiority is one of the most notable ones in the Hotchkiss systems. Exact similarity of details is to be remarked in the guns and mounts of the different calibers of revolving cannon. In the same way it is to be noticed in the rapid-firing guns that the three main features of breech mechanism, ammunition, and mounts, apply with equal efficiency throughout the entire range of calibers.

LIST OF MATERIAL EXHIBITED BY THE HOTCHKISS COMPANY.

(1) 37-millimeter revolving cannon, Navy model, on elastic steel support, with shield, ammunition chest, and accessories.

(2) 37-millimeter revolving cannon on field carriage with shield and limber.

(3) 47-millimeter revolving cannon on elastic support.

(4) 53-millimeter revolving cannon on non-recoil center-pivot carriage.

(5) 40-millimeter revolving cannon on flank-defense carriage.

(6) Light 37-millimeter rapid-firing gun on pivot stand, for torpedo boat.

(7) Light 37-millimeter rapid-firing gun on non-recoil carriage, with limber, for mountain and landing services.

(8) Light 47-millimeter rapid-firing gun, on non-recoil field carriage with limber.

(9) Light 57-millimeter rapid-firing gun, on non-recoil field carriage with limber.

(10) High-power 47-millimeter rapid-firing gun, on limited recoil and automatic return pivot carriage, with shield, ammunition chest, etc.

(11) High-power 57-millimeter rapid-firing gun, on elastic support, for decks of vessels, and with tube for practice firing.

(12) 65-millimeter rapid-firing gun, on limited recoil and automatic return carriage, ammunition chest, and its support.

(13) 75-millimeter rapid-firing gun, on limited recoil and automatic return carriage with shield.

(14) 10-centimeter rapid-firing gun, on center-pivot carriage with limited recoil and automatic return, ammunition chest, and its support.

(15) 42-millimeter gun, on mountain carriage, with pack saddle and harness.

(16) 42-millimeter gun, on yacht carriage.

(17) Projectiles, cartridges, metallic-cartridge cases, fuses, etc., for the different types of Hotchkiss guns.

(18) Practice tubes for guns with munitions.

(19) Guard net for vessels, with warning buoys to announce automatically the approach of torpedo boats.

HOTCHKISS REVOLVING CANNON.

This revolving cannon is well known in ordnance and artillery circles. The first model was exhibited at the Paris Exposition of 1878 and was adopted for service in France in 1879.

It combines the advantages of an explosive projectile with the rapidity of fire of the mitrailleuse, possessing at the same time the power, simplicity, and certainty of action necessary for service in time of war.

This machine gun consists of four principal parts:

(1) The group of barrels, five in number arranged equidistantly about a central axis of rotation to which they are fastened by two bronze disks or barrel plates.

(2) The breech which incloses the mechanism and supports the base of the cartridge.

(3) The mechanism for loading, firing, and extracting the empty cartridge shells.

(4) The chassis, or frame, which connects the breech with the group of barrels, and carries the trunnions.

The group of barrels is revolved by the action of a crank. The rotation is intermittent being one-fifth of a revolution of the group of barrels for each complete turn of the crank. Each turn brings one of the barrels to the firing point and one under the feed gate or loading slot where it receives a cartridge from the feed case or hopper. Each turn also pushes a loaded cartridge into one barrel and withdraws the empty shell from another. The stopping of the barrel group during the half-revolution of the crank allows sufficient time to fire the barrel in position without danger from hang-fires, and simplifies the operations of loading and extracting. The crank motion is continuous and the intermittent motion of the barrel group is caused by the shape of the cam, which catches and carries through itself one cog in the shaft pinion in a half revolution and leaves a blank for the other half revolution before engaging a second cog.

The rapidity of fire is one round for each turn of the crank and is continuous so long as cartridges are supplied.

The mechanism is very simple and not liable to get out of order. It consists of a single part for each function, thus, a loading piston, a firing bolt, a mainspring to give the impulse to the firing pin, an extractor for removing the empty shells and a worm wheel. The whole system can be dismounted without tools.

The shock of discharge is borne by the heavy breech piece and the metallic cartridge shells act as their own obturators.

The ammunition is similar to that of small arms except in size, and consists of a primed metallic cartridge case inclosing the powder charge and the projectile. which is engaged in the front end of the shell, so that the entire charge is in one piece convenient for handling and of easy preservation from deterioration by moisture.

The cartridges may be placed singly in the hopper, or supplied by a feed case, containing a certain number, engaged in the loading slot.

These guns are all rifled with uniform twist.

37-Millimeter revolving cannon (light), with conical support and mask.

(Plate I.)

This gun is intended for naval use. It is mounted upon a forked pivot, the extremities of whose arms form the trunnion beds and are furnished with cap-squares. The whole rests in a vertical cylindrical socket in the top of the conical support of sheet steel. The vertical socket and the trunnions constitute a universal joint which admits of pointing in any direction. The pointing is effected by

means of a shoulder piece or cross, attached to the left side of the piece, and the handle under the breech. The direction and elevation are given by the left hand and shoulder of the gunner, while the firing is done by turning a crank with the right hand. A second man feeds the piece from a feed case containing twenty cartridges. The operators are protected by steel shields. There is no recoil.

The gun fires three kinds of projectiles: Cast-iron shell, steel shell, and canister. The ammunition is packed in cases of sixty rounds each. The cases are furnished with hinges, turn-buttons, and rope beckets.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length of	1.180 millimeters	46.4 inches.
length of bore (20 calibers)	740 millimeters	29.1 inches.
diameter of bore	37 millimeters	1.45 inches.
weight of gun	210 kilograms	462 pounds.
support	90 kilograms	198.4 pounds.
shield	53 kilograms	116.8 pounds.
Total weight	353 kilograms	778.2 pounds.
limiting angles of fire:		
Elevation	+15 degrees	+15 degrees.
Depression	−35 degrees	−35 degrees.
Ammunition, shell, cast-iron, weight	455 grams	1 pound.
bursting charge	22 grams	.77 ounce.
steel, weight	505 grams	1.1 pounds.
canister, bursting charge	15 grams	0.5 ounces.
weight	570 grams	1.25 pounds.
powder charge for cast iron and steel shells	80 grams	2.8 ounces.
canister	60 grams	2.1 ounces.
total weight of cartridge:		
with cast-iron shell	625 grams	1.4 pounds.
steel shell	675 grams	1.5 pounds.
shrapnel	720 grams	1.6 pounds.
total length of cartridge	167 millimeters	6.57 inches.
Thickness of plate perforated by steel shell	3 centimeters	1.18 inches.
Initial velocity of cast-iron shell	402 meters	1,419 feet.
Rapidity of fire, rounds per minute	50 to 60.	

37-MILLIMETER REVOLVING CANNON (LIGHT), MOUNTED ON FIELD CARRIAGE, WITH LIMBER.

(Plate II.)

This gun is identical with the naval gun of the same caliber, except that the crank is placed on the side of the breech, instead of extending to the rear, and the frame is heavier, to withstand the rougher usage of field service.

The carriage, limber, and ammunition chest are made of steel.

The carriage is provided with a shield which, when lowered, serves as a seat for the cannoneers during the march. An elevating and traversing apparatus is attached to the trail.

The recoil is checked by friction brakes fastened to the inside of the conical naves of the wheels.

The ammunition chest of the limber has two compartments, an upper and lower. The former, opening upwards, carries 200 cartridges, stowed vertically in holes pierced in the diaphragms. The lower compartment holds ten feed cases, containing ten cartridges each, for use in rapid fire, besides a drawer and a box for the accessories, spare parts, etc.

This piece is designed as an auxiliary to field artillery in offensive operations, and to sweep the ditches and approaches of permanent works, and to impede the siege operations of an enemy in defensive operations.

Principal dimensions, weights, etc.

[See preceding piece for most of data.]

	Metric.	English.
Gun, total weight	225 kilograms	495 pounds.
Projectile, cast-iron shell, weight	455 grams	1 pound.
canister, weight	570 grams	1.25 pounds.
initial velocity, shell	402 meters	1,419 feet.
Carriage, weight	250 kilograms	551.1 pounds.
weight of shield and appurtenances	100 kilograms	220.4 pounds.
height of center of trunnions	890 millimeters	35 inches.
diameter of wheels	1,150 millimeters	45.2 inches.
limiting angles of fire:		
Elevation	+14 degrees	+14 degrees.
Depression	−5 degrees	−5 degrees.
Horizontally	4 degrees	4 degrees.
Limber, weight, empty	275 kilograms	605 pounds.
loaded	485 kilograms	1,452 pounds.
number of rounds transported	300	300.
Total weight of gun, carriage, limber, ammunition, etc	1,060 kilograms	2,337 pounds.

47-MILLIMETER REVOLVING CANNON (NAVAL) MOUNTED ON AN ELASTIC SUPPORT.

This piece, like the 37-millimeter gun, is intended for naval use, but being heavier it can not be used in boats, and is mounted on an elastic support which is bolted to the decks of vessels. It is pivoted similarly to the above-mentioned gun, and has but little recoil.

The gunner trains the piece by means of the shoulder-piece and the pistol-grip attached to the under side of the breech. This grip is furnished with a trigger which enables the gunner to fire at the desired moment. An assistant turns the crank at the side, which makes one revolution for each shot, and is arrested automatically when the piece is ready for firing.

The energy of the projectile at the muzzle is nearly 2.5 times that of the 37-millimeter gun, or 10.33 meter-tonnes instead of 4.12 meter-tonnes. Its energy is sufficient to disable torpedo boats or to penetrate the unarmored parts of present naval vessels.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	1,730 millimeters	68.1 inches.
length of bore (25 calibers)	1,175 millimeters	46.2 inches.
diameter of bore	47 millimeters	1.85 inches.
weight of piece	575 kilograms	1,265 pounds.
support	282 kilograms	621.7 pounds.
total weight of gun and support	857 kilograms	1,884.4 pounds.
limiting angles of fire—		
Elevation	+ 20 degrees	+ 20 degrees.
Depression	− 20 degrees	− 20 degrees.
Ammunition, cast-iron shell, weight	1,075 grams	2.36 pounds.
bursting charge	45 grams	1.6 ounces.
steel shell, weight	1,115 grams	2.45 pounds.
canister, bursting charge	45 grams	1.6 ounces.
weight	1,115 grams	2.45 pounds.
number of balls	30	30.
powder charge (common)	200 grams	7 ounces.
cast-iron shell	1,505 grams	3.3 pounds.
total weight of cartridge with steel shell and canister.	1,550 grams	3.4 pounds.
total length of cartridge	235 millimeters	9.25 inches.
Initial velocity	425 meters	1,394.4 feet
Thickness of plate perforated by steel shell	4.5 centimeters	1.77 inches.

53-MILLIMETER REVOLVING CANNON MOUNTED ON CENTER-PIVOT CARRIAGE.

(Plate III.)

This is the heaviest revolving cannon that has been constructed, but it is exactly similar to the 37 and 47 millimeter guns.

The carriage is center-pivot non-recoil construction, intended to be bolted to the decks of war vessels or to the platforms of position and seacoast batteries on land. It is supplied with an elevating apparatus and a traversing gear for pointing.

The average rapidity of fire is from thirty to forty rounds per minute. The piece is served by a gun detachment of three men—the gunner, with a man to supply ammunition, and another to turn the crank.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	2,140 millimeters	84.25 inches.
length of bore (27 calibers)	1,431 millimeters	56.3 inches.
diameter of bore	53 millimeters	2.09 inches.
weight of piece	1,000 kilograms	2,204.6 pounds.
carriage	760 kilograms	1,675.5 pounds.
limiting angles of fire—		
Elevation	+ 20 degrees	+ 20 degrees.
Depression	− 10 degrees	− 10 degrees.
Ammunition, shell, cast-iron, weight	1.630 kilograms	3.58 pounds.
bursting charge	70 grams	2.5 ounces.

Principal dimensions, weights, etc.—Continued.

	Metric.	English.
Ammunition, shell, steel, weight	1.630 kilograms	3.58 pounds.
canister, bursting charge	60 grams	2.1 ounces.
weight	1.920 kilograms	4.22 pounds.
number of balls	58	58.
powder charge, shell	410 grams	14.3 ounces.
canister	310 grams	10.9 ounces.
total weight of cartridge with shell	2.345 kilograms	4.5 pounds.
canister	2.525 kilograms	5.57 pounds.
total length of cartridge	315 millimeters	12.42 inches.
Initial velocity of shell	425 meters	1,394.3 feet.
Thickness of plate perforated by steel shell	6 centimeters	2.36 inches.

40-MILLIMETER FLANK-DEFENSE REVOLVING CANNON MOUNTED ON FLANK-DEFENSE CARRIAGE.

(Plate IV.)

This piece differs from the other revolving cannon only in its dimensions and some details of construction. The most important difference of construction consists in rifling the five barrels each with a different twist (varying from one turn in 1 meter to one turn in 6 to 7 meters), which produces a regular and automatic dispersion of the projectiles independent of any movement of the piece.

The metallic carriage has two cheek plates, and a trail provided with a cutter which is sunk in the ground when the piece is in battery, and together with the wedge brakes hold the carriage firmly in position. Four heavy iron pickets assist in maintaining the immobility of the carriage. Once the gun is pointed, elevated or depressed at the desired angle, and the recoil plate buried, the wheel brakes, the elevating screw, and regulator of the distributing table are clamped in position, and the pickets put in place. The gun can then be fired in darkness, smoke, or fog without further care. The distributing table turns on a support concentric with the left trunnion, and can be adjusted to insure the juxtaposition of the cartridges at all angles of fire, and thus the regular feeding of the piece is secured.

The carriage is furnished with a metallic shield to protect the gunner.

The primed metallic shell is charged with 90 grams of powder (MC_{30}) secured by a felt wad and a case of brass inclosing twenty-four spherical balls of hardened lead (diameter 17.8 millimeters, weighing 32 grams each), arranged in eight layers of three each. The interstices are filled with sawdust compressed. The end of the case is closed by a sheet metal disk, over the rounded edges of which are hammered down the fringed ends of the cartridge case. This disk forms a dangerous projectile for short distances.

The normal rapidity of fire is about sixty rounds per minute, corresponding to one thousand five hundred dangerous fragments per minute (twenty-five per round).

With skilled gunners ninety rounds per minute may be attained, or two thousand two hundred and fifty projectiles per minute delivered over the dangerous zone.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	1,790 millimeters	70.4 inches.
diameter of bore	40 millimeters	1.57 inches.
weight of piece	528 kilograms	1,162 pounds.
Carriage, weight of, with shield	660 kilograms	1,455 pounds.
height of trunnions	1,200 millimeters	47.24 inches.
Cartridge, weight of	1,110 grams	2.5 pounds.
total length	206 millimeters	8.1 inches.
number of dangerous fragments	25	25.
powder charge	90 grams	3 ounces.

HOTCHKISS RAPID-FIRING GUNS.

Plates V, VI, AND VII.

The invention of this unique system of ordnance marks a radical advance in light high-power guns.

The bodies of the light models are formed from a single steel forging, while the high-power types are made from two forgings, one forming the tube, the other the jacket carrying the trunnions.

The tube and jacket are assembled under carefully computed shrinkage. The tube is still further secured by a locking-ring screwed on the front end of the jacket, engaging threads cut on both jacket and tube.

The physical properties of the metal for tubes and jackets are the same; the forgings being received from manufacturers under restrictions identical with those controlling the reception of gun forgings in French manufacturing arsenals. The forgings are received rough-turned, bored, tempered, and tested. The shrinkages for developing the elastic strength of the combination to the best advantage are carefully calculated from the results of the mechanical tests, and applied in the fabrication.

In developing this system of guns care has been taken to avoid an extreme subdivision of calibers. The method adopted has been to establish a few calibers widely separated and then to develop the ammunition and mounts so as to give each caliber its widest range of service. This system was deemed preferable to introducing a great variety of calibers for the various services.

The guns are named from their metrical calibers in countries where the metric system is employed, and from the weight of the projectile in countries which use English measure.

In those cases where two guns of the same caliber are made, the lighter is designed to use the ammunition of the revolving cannon and the other to develop a higher power. The high-powered gun is regarded as the standard one, the lighter being designed for those naval powers who have already the revolving cannon and prefer to retain an interchangeable ammunition and to avoid confusion.

The bores of the 37 and 49 millimeter guns, and the 42-millimeter mountain guns, are rifled with a uniform pitch; all the others have the increasing twist.

All the bores have the right-handed twist. The width of lands in all the guns is very narrow compared with the width of the grooves.

The powder chamber is as small in diameter as the charge will admit.

The breech is squared, with rounded corners in rear of the powder chamber, and somewhat enlarged to give a larger bearing-surface to the breech block.

The breech mechanism, which is similar for all the calibers, is a vertical wedge operated by a lateral lever which opens and closes the breech, extracts the empty shell, and cocks the hammer or lock.

In opening, the block is allowed to fall freely until it brings up against a stop bolt which engages in a vertical groove in the left side of the block. This sudden motion gives an impulse to the empty shell and throws it clear of the piece.

The block is rectangular in cross-section, with rounded corners. Its front face is normal to the axis of the bore, and its rear face slightly inclined. There is a narrow cavity slotted up the middle of the block to permit the sweep of the hammer. The mechanism is placed in the front lower quarter, and hence does not weaken the block.

This arrangement of the mechanism is peculiar to the Hotchkiss system, is of great importance to rapid-firing guns, and possesses the following advantages:

(1) It is completely housed in the breech of the gun.

(2) It is secured against injuries from external causes.

(3) All pieces are constantly visible.

(4) They can be renewed or changed at will, whether the block be open, closed, or removed from the gun.

(5) It is impossible for a broken part of the mechanism to jam the action.

Hence, any injured piece can be seen and removed without delay and thus prevent the disabling of the gun. The mechanism is very simple and is composed of the minimum number of parts. Its functions are:

(1) To open the breech.

(2) To close the breech.

(3) To fire the gun.

(4) To extract the empty cartridge-case.

After being started by the lever the block falls vertically of its own weight, hence the action of the opening and closing mechanism is to lift the block straight up in closing, and to keep it from falling open when closed, or from falling out when the gun is open.

When the breech is closed the block is kept from falling by the crank being slightly past the vertical to the front, and also by an automatic spring catch on the handle.

A large circular slot with a steep bevel in front is formed in the top of the block to facilitate loading. When the block is down this is in the prolongation of the bore of the chamber.

THE FIRING MECHANISM.

This comprises the following parts, viz: (1) The hammer, (2) the rocking shaft or tumbler, (3) the swivel, (4) the mainspring, (5) the sear, (6) the sear spring, and (7) the trigger.

The hammer is pivoted on the tumbler and is cocked by the movement of the lever in opening the block. The end of the rocking shaft or lever projects from the right side of the breech and carries a short lever or cocking arm, and on the crank axle is another short lever or cocking toe. In opening the breech the toe presses on the arm and turns the tumbler, throwing the hammer back.

To hold the hammer at full cock there is a notch on the tumbler, and a stud on the sear drops into it and is retained there by the pressure of the sear spring.

The mainspring, with two branches or arms, has its elbow inserted in a recess in the block. The free end of the upper branch bears upon the under side of a toe projecting from the rear of the tumbler, while the lower arm engages the swivel by means of a claw. The swivel at its upper end is pivoted to the forward projecting arm of the tumbler; hence both branches of the mainspring act upon the tumbler without causing friction to the tumbler shaft itself.

To fire the gun the free end of the sear projects a little beyond the rear end of the breech block, and by pressing down on it the cock notch is freed and the hammer flies forward under the influence of the mainspring and strikes the cartridge primer and ignites the charge.

EXTRACTOR.

The steel extractor is a bar with a claw on the front end to engage the cartridge head. It moves parallel to the axis of the piece in a recess cut in the left side of the breech. The rear end of the extractor is armed with a projecting stud which slides in a groove very slightly inclined at first, and then at the upper end it suddenly slopes to the rear, making an angle of 45° with the vertical. This groove is cut in the breech block. By this arrangement the effect at the beginning of the downward movement of the breech block starts the extractor slowly toward the rear with a powerful leverage, loosen-

ing the shell from the walls of the chamber, and when the block has descended sufficiently to unmask the bore, the sudden change in direction of the extractor-stud groove gives the extractor a quick motion to the rear, which throws the empty shell clear of the bore.

ACTION OF THE MECHANISM.

The breech is opened and the hammer cocked by pulling the crank handle to the rear. When the handle commences to move the crank stud is drawn back in the part of its groove concentric with the axis of the crank. During this movement the block does not move, but the cocking toe presses on the cocking arm and cocks the hammer. The crank stud then enters the straight part of its groove and the block commences to descend. During this movement of the block the extractor acts as above described and throws the empty shell clear of the piece.

The gun is now ready for loading.

The new charge is passed into the chamber until the head brings up against the extractor hook, and the breech block is closed by turning the handle towards the front. As the block rises its inclined upper corner pushes the cartridge and extractor close home. "When the block is entirely up, its face bears tightly against the head of the cartridge, and the crank has passed the vertical position, so that the block is held securely in three different ways—by its own weight, pressing on the crank past the center, by the reaction of the crank and handles in recoil, and by the small spring catch."

In this position the cocking toe is clear of the arm, so that the hammer can act. The top branch of the trigger also rests against the sear and the gun is ready for firing.

SECURITY OF THE SYSTEM.

The safety of the system may be considered as absolute.

The cocking toe on the crank axle allows space for the cocking arm in the tumbler, which carries the hammer, to pass over its whole course only when block is fully closed and locked. The trigger does not bear on the free arm of the sear until the breech block is home.

The breech can not be opened by the presence of the powder gases at the moment of firing.

The primer can not be ignited before the block is fully closed because only in that position is the firing-pin hole opposite the primer.

37-MILLIMETER RAPID-FIRING GUN (1-POUNDER; CALIBER, 1.45") MOUNTED ON A PIVOT AND SOCKET.

(Plate VIII.)

This is the smallest rapid-firing gun made and uses the ammunition of the light 37-millimeter revolving cannon. It is easily manip-

ulated and can be transported and served by one man. It is mounted on the fork of a vertical pivot, whose socket stand can be bolted in any convenient place on a vessel. The metallic shield carried by the pivot protects the firer, who aims the piece by means of the shoulder piece on the left side. He fires and manipulates the breechblock with his right hand and loads with his left.

This gun is designed for the armament of a vessel's tops, for small torpedo boats and launches.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length with shoulder piece	1,167 millimeters	45.9 inches.
length of piece	842 millimeters	33.1 inches.
length of bore (20 calibers)	739 millimeters	29.1 inches.
weight of piece	33 kilograms	72.7 pounds.
pivot and socket, stand	45 kilograms	99.2 pounds.
shield	45 kilograms	99.2 pounds.
total weight with mounting and shield	123 kilograms	371.2 pounds.
initial velocity of cast-iron shell	402 meters	1,320 feet.
Ammunition, weight of projectile, cast-iron shell	455 grams	1 pound.
steel shell	505 grams	1.11 pounds.
canister	570 grams	1.25 pounds.
powder charge for cast-iron shell	80 grams	2.82 ounces.
steel shell	80 grams	2.82 ounces.
canister	60 grams	2.1 ounces.
Weight of loaded cartridge with—		
cast-iron shell	625 grams	1.38 pounds.
steel shell	675 grams	1.49 pounds.
canister	720 grams	1.59 pounds.
Rapidity of fire, about forty rounds per minute		

37-MILLIMETER RAPID-FIRING GUN, WITH LANDING CARRIAGE FOR BOATS AND ON MOUNTAIN CARRIAGE WITH LIMBER. (1-POUNDER; CALIBER 1.45".)

(Plate IX.)

This is the ordinary light 37-millimeter rapid-firing gun with its pivot. This pivot is simply placed in the socket between the cheeks of the carriage and held there by a screw clamp.

The gunner is seated upon the trail saddle and points the piece by means of the shoulder piece and pistol grip. A cannoneer seated upon the trail assists in holding down the carriage and thus suppresses the recoil. The light 37-millimeter revolving cannon can be used upon this same carriage.

The limber is a light structure of steel carrying two ammunition chests with sixty rounds each and a case holding the accessories.

The carriage is intended to be handled by hand and was specially designed for use in rough, broken country, and for landing parties. The trail is in halves, so as to divide the weight and render the transport by hand easy in case of necessity.

Principal dimensions, weight, etc,

	Metric.	English.
Gun, weight of gun with shoulder piece	33 kilograms	72.7 pounds.
weight of pivot	18 kilograms	39.7 pounds.
Carriage, upper part	47 kilograms	103.6 pounds.
trail	51 kilograms	112.4 pounds.
two wheels	46 kilograms	101.4 pounds.
total weight	144 kilograms	317.4 pounds.
Total weight of gun and carriage	195 kilograms	429.9 pounds.
Limber, weight, empty	140 kilograms	308.6 pounds.
loaded (120 cartridges)	195 kilograms	429.9 pounds.
Ammunition, weight of projectile, cast-iron shell	455 grams	1.0 pounds.
canister	570 grams	1.25 pounds.
Total weight of cartridge—		
cast-iron shell	625 grams	1.38 pounds.
canister	720 grams	1.59 pounds.
powder charge, cast-iron shell	80 grams	2.82 ounces.
canister	60 grams	2.1 ounces.
Initial velocity	402 meters	1,320 feet.
Rapidity of fire about 40 rounds per minute		

LIGHT 47-MILLIMETER RAPID-FIRING GUN MOUNTED ON NON-RECOIL FIELD CARRIAGE, WITH LIMBER. (2½ POUNDER; CALIBER, 1.85 INCHES.)

(Plate X.)

The description of this piece is essentially the same as that already given above.

The distinctive feature is the carriage. The practicability of a rapid-firing gun in the field demands the employment of a non-recoil carriage, in order that the running into battery and the readjustment of the direction and elevation after each shot may not destroy the advantages of quick loading and firing.

The Hotchkiss non-recoil field carriage for rapid-firing guns fulfills this condition, since, after being once pointed, it permits a series of consecutive shots to be fired without further change or adjustment.

It consists of three distinct parts:

(1) The body, composed of two flasks connected by steel transoms forming the trail and carrying the axle and the wheels.

(2) The chassis resting on the body, to which it is connected by the bolster pin at the front end. This arrangement permits it to traverse an angle of about 4°, or 2 degrees on each side of the meridian plane of the carriage, under the action of traversing wheel.

(3) The top carriage, which slides upon the chassis and carries the gun and elevating apparatus. It is fastened to the chassis by springs inclining to the rear, which act at the instant of firing, first to take up the recoil by their elastic resistance and the friction which the normal component of this resistance develops between the top carriage and the chassis, and then to bring the piece back to the firing position.

This counter-recoil is produced without shock, owing to the variable inclination of the springs and the varying friction produced thereby.

The resistance of the carriage to recoil under fire is still further increased by two shoe brakes joined by a steel or iron rod and fastened eccentrically to the axle by two steel clamps or bolts.

On the march the brake is hooked up to the under side of the trail, and is let down in preparing for action, when the shoes exert a wedging action on the circumferences of the wheels.

The limber and ammunition chest are made of steel. The latter opens to the rear and contains the cartridges packed in feed cases which permit a rapid supply of ammunition to the piece.

The implements are borne by the carriage.

The rapidity of fire is about twenty-five rounds per minute.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	1,325 millimeters	52.2 inches.
length of bore (25 calibers)	1,175 millimeters	46.3 inches.
weight of piece	95 kilograms	211.6 pounds.
Ammunition, weight of projectile, cast-iron shell	1,075 grams	2.36 pounds.
canister	1,110 grams	2.44 pounds.
powder charge (common)	200 grams	7.06 pounds.
initial velocity	425 meters	1,394.3 feet.
weight of cartridge, with cast-iron shell	1,505 grams	3,31 pounds.
canister	1,550 grams	3.41 pounds.
total length of cartridge	235 millimeters	9.25 inches.
Carriage, weight	355 kilograms	782.6 pounds.
height of center of trunnions	930 millimeters	36.61 inches.
width of tread	1,110 millimeters	43.31 inches.
diameter of wheels	1,150 millimeters	45.27 inches.
limiting angles of fire:		
Elevation	+15 degrees	+15 degrees.
Depression	—5 degrees	—5 degrees.
Horizontally	4 degrees	4 degrees.
Limber, weight, empty	395 kilograms	870.8 pounds.
loaded	700 kilograms	1,543.2 pounds.
number of rounds in chest	189	189.
Total weight of gun, carriage, and limber, fully loaded	1,150 kilograms	2,535.3 pounds.

57-MILLIMETER RAPID-FIRING GUN, MOUNTED ON NON-RECOIL FIELD CARRIAGE, WITH LIMBER. (6-POUNDER; CALIBER, 2.24 INCHES.)

(Plate XI.)

The arrangement and action of this carriage and limber are identical with those of the preceding; they differ chiefly in the dimensions. The wheels have shoes to act as brakes going down hill and as chocks for recoil in firing.

The gun is composed of a tube and trunnion-bearing jacket. The breech mechanism is the same as that of all rapid-firing guns of the same system.

The rapidity of fire is about twenty rounds per minute.

Principal dimensions, weight, etc.

	Metric.	English.
Gun, weight of	235 kilograms	518 pounds.
length of piece	1,895 millimeters	74.6 inches.
length of bore (.30 caliber)	1,710 millimeters	67.3 inches.
Ammunition, weight of projectile:		
cast-iron shell	2.720 kilograms	6 pounds.
shrapnel	2.720 kilograms	6 pounds.
canister	2.920 kilograms	6.44 pounds.
powder charge	620 grams	1.37 pounds.
initial velocity	450 meters	1,476 feet.
total weight of cartridge	3.970 kilograms	8.75 pounds.
total length of cartridge	406 millimeters	16 inches.
Carriage, weight	600 kilograms	1,322.7 pounds.
height of center of trunnions	1,085 millimeters	42.7 inches.
tread	1.500 meters	59 inches.
diameter of wheels	1.400 meters	55.1 inches.
limiting angles of fire—		
elevation	+ 15 degrees	+ 15 degrees.
depression	— 5 degrees	— 5 degrees.
horizontally	4 degrees	4 degrees.
Limber, weight, empty	450 kilograms	992 pounds.
loaded	850 kilograms	1.896 pounds.
number of rounds in ammunition chest	72	72.
Total weight of gun, with carriage and limber	1,695 kilograms	3,736.8 pounds.

HIGH-POWER 47-MILLIMETER RAPID-FIRING GUN MOUNTED ON RECOIL CARRIAGE; (3-POUNDER—CALIBER 1.85 INCHES).

(Plate XII.)

This is a high power gun, and has a steel jacket with the Hotchkiss breech mechanism. It is mounted upon a limited recoil carriage with automatic return, composed of a cradle carrying trunnions and fitted with hydraulic brakes and returning springs symmetrically placed with respect to the axis of the piece. The correlation of this system of hydraulic brakes and springs is such that the recoil is diminished and the gun brought back to the firing position without shock after each shot.

The maximum recoil is about 10 centimeters (about 4 inches) and is exerted always in the direction of the axis of the piece.

The cradle trunnions rest upon a pivot, which is engaged in a socket on a stand, so as to afford a kind of universal joint, enabling the gun to be pointed in all directions by means of the shoulder piece and handle.

The piece is fired by a lanyard. The pivot carries a steel shield to protect the gunner.

Three kinds of projectiles are used—cast iron shell, steel shell, and canister.

The cast iron and steel shells are armed with the Hotchkiss percussion base fuse.

The steel shell will perforate an iron plate nearly 4 inches thick (10 centimeters). The ammunition is packed in cases containing 16 rounds each.

This gun was originally designed for the French Navy and was intended to satisfy the condition of a very light high power gun, capable of penetrating the non-armored parts of war vessels at usual fighting distances, and of delivering an accurate and sustained fire of not less than twelve rounds per minute with the employment of not more than three men.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	2.048 meters	80.6 inches.
length of bore (.40 caliber)	1.880 meters	74 inches.
diameter of bore	47 millimeters	1.85 inches.
weight of piece	230 kilograms	507 pounds.
Ammunition, cast-iron shell, weight	1.500 grams	3.3 pounds.
bursting charge	60 grams	2.10 ounces.
steel shell, weight	1.500 grams	3.3 pounds.
bursting charge	50 grams	1.76 ounces.
canister, weight	1.500 grams	3.3 pounds.
number of balls	40	40.
powder charge for cast iron and steel shell	780 grams	27.53 ounces.
initial velocity	610 meters	2,001.3 feet.
total length of cartridge with—		
cast-iron shell	522 millimeters	20.55 inches.
canister	511 millimeters	20.11 inches.
steel shell		
total weight of cartridge, with—		
shell	2.894 kilograms	6.37 pounds.
canister	2.803 kilograms	6.18 pounds.
Carriage, weight without shield	290 kilograms	639.3 pounds.
weight of shield and appurtenances	135 kilograms	297.6 pounds.
thickness of shield	16 millimeters	0.63 inch.
limiting angles of fire, elevation	+20 degrees	+20 degrees.
depression	−25 degrees	−25 degrees.
horizontally	360 degrees	360 degrees.
Total weight of carriage	425 kilograms	937 pounds.
Total weight of gun and carriage	645 kilograms	1,422 pounds.

HIGH-POWER 57-MILLIMETER RAPID-FIRING GUN MOUNTED ON ELASTIC STAND; (6-POUNDER; CALIBER, 2.24 INCHES).

(Plate XIII.)

This piece is similar in construction to the 47 millimeter gun, but the energy of its projectile is about twice that of the latter gun. It is mounted on the Hotchkiss system upon a pivot carrying the trunnions, the pivot engaging in a socket carried by an elastic support.

The elasticity of the support admits of a recoil of a little more than three-quarters of an inch (about 2 centimeters), so that the reaction on the deck is kept within such limits that it may be employed upon the decks of light cruisers and gunboats.

The pointing and firing are effected by the shoulder piece and the trigger of the pistol grip.

The gunner opens and closes the breech while the cartridges are introduced by an assistant.

The steel shield is attached to the pivot and is traversed horizontally with the gun.

For practice firing this model and all smaller calibers are furnished with a firing tube using the small-arm service cartridge. This tube, which has the exterior form of the gun cartridge, is inserted in the chamber, from which it is extracted after each shot, the same as the ordinary service shells.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	2.480 meters	97.6 inches.
length of bore (.40 caliber)	2.280 meters	89.8 inches.
diameter of bore	57 millimeters	2.24 inches.
weight of piece	365 kilograms	805 pounds.
Ammunition, cast-iron shell, weight	2.720 kilograms	5.99 pounds.
bursting charge	85 grams	2.99 ounces.
steel shell, weight	2.720 kilograms	5.99 pounds.
bursting charge	115 grams	4 ounces.
canister, weight	2.920 kilograms	6.44 pounds.
number of balls	80	80
powder charge, cast-iron and steel shells	930 grams	2.05 pounds.
canister	730 grams	1.60 pounds.
total length of cartridge	482 millimeters	18.97 inches.
weight of cartridge	4.400 kilograms	9.7 pounds.
initial velocity	600 meters	1,968.5 feet.
Carriage, weight of carriage without shield	4[illegible]0 kilograms	1,114.1 pounds.
shield and appurtenances	158 kilograms	347.7 pounds.
thickness of shield	19 millimeters	0.75 inch.
total weight of	618 kilograms	1,362.4 pounds.
limiting angles of fire, elevation	+20 degrees	+20 degrees.
depression	-25 degrees	—25 degrees.
horizontally	360 degrees	360 degrees.
Total weight of gun and carriage	983 kilograms	
Maximum rapidity of fire per minute, rounds	25	[illegible]
Thickness of plate perforated by steel shell	12 millimeters	4.91 inches.

65-Millimeter rapid-firing gun mounted on recoil carriage and elastic support (9-pounder—caliber 2.56 inches).

(Plates XIV, XV, and XVI.)

This gun is similar to the smaller Hotchkiss guns of the same system.

In designing the piece the weight was fixed at one hundred and fifty times that of its projectile, thus giving more metal than necessary, but this increase secures two advantages, viz:

(1) It allows the slender chase to be stiffened, increasing the accuracy of fire since it lessens the vibrations, and

(2) The additional weight absorbs some of the recoil and reduces the strains on the mounting without affecting the mobility of the gun.

The recoil strains of these light high-powered guns are very severe upon the mount and fastening, even under the most favorable circumstances.

The gun was designed to cover the demand for naval rapid-firing guns with an initial velocity of not less than 610 meters (2,000 feet), and was given a chamber capacity and travel of shot sufficient to secure 615 meters (2,016 feet), with a maximum pressure of not over 2,500 kilograms per square centimeter (16 tons per square inch).

The dimensions and form of rifling are the same as for the smaller calibers. The right-handed twist is increasing from 0° to 6° 30′, so as to permit the use of the minimum thickness of band that is possible without stripping. This step strengthens the shell at the slot cut for the band and prevents breaking in piercing armor, by diminishing the depth of the slot.

For use on board vessels it is mounted on a limited recoil carriage with automatic return or counter recoil, similar to that of the 47 and 57 millimeter guns. The pivot is inserted in the socket of an elastic support at a height above the deck sufficient to permit of easy manipulation.

The gun itself is mounted on a cradle. The recoil is less than 5 inches, and is controlled by hydraulic cylinders (oil capacity, 2½ liters—about 2¼ quarts) in front of the trunnions, while springs seated in cylinders behind the trunnion force the gun back into battery. The shoulder piece is bolted to the left cheek of the cradle and is independent of the gun during recoil. With the shoulder piece in position the system is *in equilibrio* on the cradle trunnions.

Screw clamps hold the gun in position horizontally and in elevation. A short cylinder projecting from the rear of the cartridge case shield forms a fixed handle by means of which the gunner's right hand can be used in aiming and firing. This handle incloses a moveable cylinder with a round projecting head attached to the firing lanyard.

The gun is fired from the shoulder as easily as the smaller calibers. The rapidity of fire is about the same.

The ammunition employed with this piece consists of the common cast-iron shell, the steel shell, the canister shot, and a shrapnel furnished with a combination fuse.

The common (cast-iron) shell, the steel shell, and the canister for the 65-millimeter gun are exactly similar to those for the smaller calibers.

The Hotchkiss shrapnel has a steel tubular body with interior longitudinal grooves cut to weaken it and make it break up readily. A hollow cast-iron head is screwed into the front end and forms the magazine and seat for the time fuse. The body tube is filled with bullets symmetrically distributed with respect to the axis, the layers being separated by cast-iron diaphragms so shaped as to fill the cavities. These diaphragms are molded and cast so as to break up easily. The bottom is closed by a steel disk screwed in.

The cartridges are inclosed in metallic cases containing eight rounds each. These cases are placed upon an inclined pedestal or stand near the gun, to facilitate the loading. The cases weigh about 80 kilograms (176 pounds).

The Hotchkiss Company makes to order either the Hotchkiss made-up case or the solid-head case, but it considers the less expensive made-up cases as efficient as the solid-head case, and for this caliber they can be furnished at less than half the cost of the solid-head one.

The faults which develop in these large cartridge cases are as follows:

(1) Cracks or holes developed in the body of the case. These are due either to originally poor or unsuitable metal, or to grit or fouling ground into the metal in drawing.

(2) The body sometimes buckles longitudinally. This is found to be due to the sudden vaporization of grease or damp between the case and the wall of the chamber. With a fairly dry case or chamber it does not occur.

(3) Transverse cracking at the neck. This is due to a bad shape of connecting cone between the powder and shell chamber.

(4) Burnt metal at the mouth of the case. This is due to either too thin metal at this point, or to too poor or overworked metal.

These faults apply to all metallic cases and are remediable.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	3.025 meters	119.09 inches.
length of bore (43 calibers)	2.823 meters	111.14 inches.
diameter of bore.	65 millimeters	2.56 inches.
weight of piece	600 kilograms.	1.320 pounds.
Ammunition, cast-iron shell, weight	4 kilograms	8.8 pounds.
bursting charge	112 grams	3.84 ounces.
steel shell, weight	4 kilograms	8.8 pounds.
bursting charge	145 grams	5.11 ounces.
canister, weight	4.225 kilograms	9.3 pounds.
number of balls.	169	159.
shrapnel, weight	4 kilograms	1.8 pounds.
bursting charge	55 grams	1.94 ounces.
total number of fragments	125	125

Principal dimensions, weights, etc.—Continued.

	Metric.	English.
Ammunition, powder charge, cast-iron and steel shells.	1.650 kilograms	3.63 pounds.
canister and shrapnel	1.450 kilograms	3.2 pounds.
initial velocity of shell	630 meters	2.067 feet.
total weight of cartridge with shell	7.150 kilograms	15.76 pounds.
canister and shrapnel	7.185 kilograms	15.83 pounds.
total length of cartridge	668 millimeters	26.3 inches.
Carriage, weight without mask	750 kilograms	1,653.4 pounds.
Limiting angles of fire:		
elevation	+15 degrees	+15 degrees.
depression	−15 degrees	−15 degrees.
horizontally	360 degrees	360 degrees.
Total weight of gun and carriage	1,350 kilograms	2,976.2 pounds.
Rapidity of fire per minute, about	20	20
Thickness of plate perforated by steel shell	16 millimeters	6.3 inches.

75-MILLIMETER (2.97 INCHES) RAPID-FIRING GUN, MOUNTED ON LIMITED RECOIL AND AUTOMATIC RETURN CARRIAGE, WITH ELASTIC SUPPORT AND SHIELD.

This piece in its construction and ballistic properties is analogous to the other Hotchkiss high-power guns. It is the heaviest made for pointing and firing by means of the shoulder-piece.

The weight of the projectile, 6.4 kilograms (14.1 pounds), is four times that of the spherical shot of the same diameter. The initial velocity is about 620 meters (or about 2,034 feet per second).

The muzzle energy is 125 metre-tonnes (or 403.6 foot-tons).

The steel shell will pierce wrought-iron plates of 190 millimeters (7.48 inches) in thickness.

Where the use of such devices are admissible, an elevating apparatus and traversing gear are supplied.

Maximum rapidity of fire about twenty rounds per minute.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	3.855 meters	151.77 inches.
length of bore (45 calibers)	3.375 meters	132.86 inches.
diameter of bore	75 millimeters	2.97 inches.
weight of piece	830 kilograms	1,829.84 pounds.
Ammunition, cast-iron shell, weight	6.400 kilograms	14.1 pounds.
bursting charge	200 grams	7.05 ounces.
steel shell, weight	6.400 kilograms	14.1 pounds.
bursting charge	200 grams	7.05 ounces.
canister, weight	6.400 kilograms	14.1 pounds.
number of balls	323	323.
shrapnel, weight	6.400 kilograms	14.1 pounds.
bursting charge	100 grams	3 ounces.
powder charge for cast-iron and steel shells	3.200 kilograms	7.05 pounds.
powder charge for shrapnel and canister	3.100 kilograms	6.83 pounds.

Principal dimensions, weights, etc.—Continued.

	Metric.	English.
Ammunition, initial velocity of shell	620 meters	2,034.1 feet.
cartridge, total length	880 millimeters	34.65 inches.
total weight	7.700 kilograms	16.98 pounds.
Carriage, weight without shield	1,000 kilograms	2,204.6 pounds.
weight of shield and appurtenances	180 kilograms	396.8 pounds.
total weight of	1,180 kilograms	2,601.5 pounds.
Limiting angles of fire:		
elevation	+ 15 degrees	+ 15 degrees.
depression	− 15 degrees	− 15 degrees.
horizontally	360 degrees	360 degrees.
Total weight of gun and carriage	2,910 kilograms	6,415.4 pounds.

10-CENTIMETER (3.937 INCHES) RAPID-FIRING GUN, MOUNTED ON CENTER-PIVOT, LIMITED RECOIL, AND AUTOMATIC RETURN CARRIAGE.

(Plate XVII.)

This gun may be classed among those capable of piercing armored vessels, since its projectile, weighing 15 kilograms (33.069 pounds), with a muzzle velocity of 600 meters (1,968.5 feet), can pierce a plate 20 centimeters (7.874 inches) in thickness.

It can deliver from ten to twelve rounds per minute, and can be pointed and fired by a single man with the same ease as a 57-millimeter (2.24 inches) gun; hence it presents advantages over the ordinary service guns.

Like the lesser calibers, it is loaded in one motion; the projectile and powder charge are united in a metallic cartridge case, which may be reloaded six or eight times, thus extending the benefits of metallic ammunition to the higher caliber.

The general construction and breech mechanism are similar to the other Hotchkiss guns.

The body of the gun is composed of the tube, rear jacket (carrying the breech mechanism), the front jacket, locking ring, and trunnion ring.

These parts are made of Creuzot steel, oil tempered and then annealed. The only differences in the breech mechanism are:

(1) The breech lever rotates 160 degrees, and its position is arranged to give the greatest leverage on account of the greater weight of the breechblock. In the smaller guns this lever only rotates about 90 degrees.

(2) There are two extractors, one on each side of the breechblock.

The ammunition is similar to the smaller guns, and consists of common shell (cast iron), steel shell, canister (or case shot), and shrapnel. All the shell employ the ordinary Hotchkiss base-percussion fuse.

The canister (or case shot) is a brass casing lined with iron tubing, divided into four segments, and is filled with cast-iron bullets.

The shrapnel is similar to that of the 65-millimeter gun and is fitted with the Elswick combination time and percussion fuse.

The Hotchkiss system of cartridge case is used, so modified that the primer carries the igniting charge. A small tubular chamber with a vent in the dome-shaped end is formed in the base of the cartridge, for the insertion of the primer. The latter is simply a blank pistol cartridge charged with fine powder. It acts like a small-arm cartridge and forms an obturating primer in the base of the cartridge.

The ammunition is packed in wooden cases of four rounds each. The case opens on top, and the sides fall for one-fourth of the length of the cartridge to facilitate its removal.

It is one of the great advantages of the system that it is applicable to the entire series of models and calibers within the limits of the use of metallic ammunition—that the breech mechanism, ammunition, and carriages are equally applicable to all calibers from 37 millimeters (1.45 inches) to 10 centimeters (3.94 inches).

The carriage for this gun is similar to those for the 65-millimeter gun, except the modifications made necessary by the higher power and longer dimensions of the piece.

The gun is pointed approximately by the shoulder-piece, and then the rectification is made both in elevation and azimuth by worm-gears actuated by hand wheels.

The piece is allowed about 15 inches recoil in order to reduce the strain on the deck. The carriage has an inclined shield (steel) to protect the gunners against machine-gun fire.

Should smokeless powder prove to be of general application and use, then we may look for a considerable increase in velocity and value of rapid-firing guns.

Studies are being made of guns built on this system, of higher caliber than the 10-centimeter gun.

Principal dimensions, weights, etc.

	Metric.	English.
Gun, total length	4.413 meters	173.28 inches.
length of bore (42 calibers)	4.200 meters	165.35 inches.
diameter of bore	100 millimeters	3.94 inches.
weight of piece	1,650 kilograms	3,637.6 pounds.
Ammunition, cast-iron shell, weight	15 kilograms	33.07 pounds.
bursting charge	520 grams	18.3 ounces.
steel shell, weight	15 kilograms	33.07 pounds.
bursting charge	600 grams	21.2 ounces.
canister, weight	15 kilograms	33.07 pounds.
number of balls	96	96.
shrapnel, weight	15 kilograms	33.07 pounds.
number of fragments	350	350.

Principal dimensions, weights, etc.—Continued.

	Metric.	English.
Ammunition, powder charge for—		
cast-iron and steel shells	6 kilograms	13.23 pounds.
canister and shrapnel	5 kilograms	11.02 pounds.
Initial velocity of shell	500 meters	1,968.5 feet.
Total weight of cartridge (shell)	25.300 kilograms	55.68 pounds.
Total length of cartridge	1,064 millimeters	41.89 inches.
Carriage, weight without shield	1,530 kilograms	3,373 pounds.
weight of shield and appurtenances	250 kilograms	551.1 pounds.
thickness of shield	16 millimeters	0.63 inches.
total weight of carriage	1,780 kilograms	3,924.1 pounds.
limiting angles of fire—		
elevation	+12 degrees	+12 degrees.
depression	—8 degrees	—8 degrees.
horizontally	360 degrees	360 degrees.
Weight of gun and carriage	3,430 kilograms	7,561.8 pounds.

12-CENTIMETER (4.72-INCH), HOTCHKISS RAPID-FIRING GUNS.

PLATE XVIII.

There are two 12-centimeter guns, the light and the high-power gun. The design and construction are similar to the 10-centimeter gun.

The light 12-centimeter gun has two projectiles, a light and a heavy one. In the high-power 12-centimeter there is an increase in dimensions and weight to correspond to the increase of strength required. The dimensions, weights, and balistic data for these pieces are given below.

These guns have not yet been issued to any service, as they have been but recently designed. A 15-centimeter high-power gun is about to be constructed.

The 10-centimeter light, 12-centimeter high-power, 12-centimeter, and the 15-centimeter Hotchkiss rapid-firing guns were designed and worked up in all their details by Mr. Lawrence V. Benét, one of the engineers of the Hotchkiss Company. The excellence of these guns attest the simplicity and adaptability of the system.

(1) *Hotchkiss light 12-centimeter (4.72-inch) rapid-firing gun—principal dimensions, weight, etc.*

LIGHT PROJECTILE.

	Metric.	English.
Caliber	12 centimeters	4.72 inches.
Total length of gun	4,633 millimeters	182.4 inches.
Total length of bore (36.5 calibers)	4,380 millimeters	172.44 inches.
Travel of projectile in bore	3,750 millimeters	147.64 inches.
Total weight of gun with breech action	2,150 kilograms	4,740 pounds.
Estimated weight of carriage with shield	2,350 kilograms	5,181 pounds.

(1) *Hotchkiss light 12-centimeter (4.72-inch) rapid-firing gun, etc.*—Continued.

LIGHT PROJECTILE—Continued.

	Metric.	English.
Weight of projectile	16.5 kilograms	46.3 pounds.
powder charge	7.8 kilograms	17.2 pounds.
complete cartridge	30.6 kilograms	67.45 pounds.
Length of complete cartridge	936 millimeters	36.85 inches.
Brand of powder (French)	S. P^2	
Density of loading	0.924	0.924.
Initial velocity	695 meters	2,280 f. s.
Maximum pressure	25.75	16.3 tons per square inch.
Muzzle energy $\left(\frac{PV^2}{2g}\right)$	403 m. t	1,300 f. t.
Energy per square centimeter of cross section $\left(\frac{PV^2}{2g''R^2}\right)$	3.35 m. t	10.8 f. t.
Muzzle penetration in wrought iron	282 millimeters	11.1 inches.
Remaining velocity at 1,000 meters	535 m. s.	
1,000 yards		1,790 f. s.
Remaining velocity at 2,000 meters	415 m. s.	
2,000 yards		1,417 f. s.
Penetration in wrought iron at 1,000 meters	183 millimeters.	
1,000 yards		7.5 inches.
Penetration in wrought iron at 2,000 meters	124 millimeters.	
2,000 yards		5.2 inches.
Energy at 1,000 yards		812 f. t.

HEAVY PROJECTILE.

	Metric.	English.
Caliber	12 centimeters	4.72 inches.
Total length of gun	4,633 millimeters	182.4 inches.
Total length of bore (36.5 calibers)	4,380 millimeters	172.44 inches.
Travel of projectile in bore	3,750 millimeters	147.64 inches.
Total weight of gun with breech action	2,150 kilograms	4,740 pounds.
Estimated weight of carriage with shield	2,350 kilograms	5,181 pounds.
Weight of projectile	25 kilograms	55.11 pounds.
powder charge	7.8 kilograms	17.2 pounds.
complete cartridge	39.10 kilograms	86.2 pounds.
Length of complete cartridge	1,067 millimeters	42 inches.
Brand of powder (French)	WS 20-25	
Density of loading	0.924	0.924.
Initial velocity	545 meters	1,788 f. s.
Maximum pressure	2,520 kilograms per square centimeter.	16 tons per square inch.
Muzzle energy $\left(\frac{PV^2}{2g}\right)$	379 m. t	1,224 f. t.
Energy per square centimeter of cross section $\left(\frac{PV^2}{2g''R^2}\right)$	3.56 m. t	11.5 f. t.
Muzzle penetration in wrought iron	259 millimeters	10.2 inches.
Remaining velocity at 1,000 meters	462 m. s.	
1,000 yards		1,539 f. s.
2,000 meters	388 m. s.	
2,000 yards		1,316 f. s.
Penetration in wrought iron at 1,000 meters	201 millimeters.	
1,000 yards		8.1 inches.
2,000 meters	153 millimeters.	
2,000 yards		6.4 inches.
Energy at 1,000 yards		909 f. t.

(2) *High-power 12-centimeter rapid-firing gun—principal dimensions, weights, etc.*

	Metric.	English.
Caliber	12 centimeters	4.7 inches.
Total length of gun	534.5 millimeters	210.43 inches.
Total length of bore (42.5 calibers)	510 millimeters	200.79 inches.
Travel of projhctiie in bore	4,200 millimeters	165.35 inches.
Net weight of gun with breech action	3,320 kilograms	7,319.4 pounds.
Estimated weight of carriage with shield	4,000 kilograms	8,818.5 pounds.
Weight of projectile	25 kilograms	55.11 pounds.
powder charge	13.5 kilograms	29.75 pounds.
complete cartridge	45 kilograms	99.2 pounds.
Length of complete cartridge	1,334 millimeters	52.52 inches.
Brand of powder	P. B. 3	
Density of loading	0.920.	0.920.
Initial velocity	650 meters	2,133 feet.
Maximum pressure	2,500 kilograms per square centimeter.	15.9 tons per square inch.
Muzzle energy	539 meters	1,740 feet.
Energy per square centimeter of cross section	4.76 m.t	15.3 feet.
Muzzle penetration in wrought iron	340 millimeters	13.3 inches.
Remaining velocity at 1,000 meters	548 m. s.	
1,000 yards		1,826 f. s.
2,000 meters	462 m. s.	
2,000 yards		1,563 f. s.
Penetration in wrought iron 1,000 meters	262 millimeters.	
1,000 yards		10.6 inches.
2,000 meters	201 millimeters.	
2,000 yards		8.3 inches.
Energy at 1,000 yards		1,271 f.t.

42-Millimeter Mountain Gun Mounted on a Mountain Carriage; (2-Pounder; Caliber, 1.65").

(Plates XIX and XX.)

The body of this gun is made of a single piece of forged steel upon which the trunnion ring is screwed. The breech mechanism is very simple, consisting of a horizontal block or wedge, and an extractor similar to that employed in the Hotchkiss rapid-firing guns. There is no special obturator, the metallic cartridge case acting as its own gas check. The cartridge case is automatically ejected by the opening of the breechblock.

The cartridge is a metallic case which carries both the powder charge and the projectile.

The cartridge case belongs to the wrapped-metal system. The body consists of a single piece of sheet brass rolled to shape on a mandrel. The rear end is turned in, reënforced by an exterior brass cap and the whole secured to a sheet-iron disk forming the head by three rivets. A hole is pierced through the center of the iron disk whilst three fire holes are pierced excentrically through the reënforcing caps.

The flame from the primer enters the central hole in the head, lifts the elastic central parts of the cup and penetrates the charge by means of the fire holes. The pressure from the gases of the ignited charge

acting toward the rear closes the metal over these holes and prevents the escape of gas to the rear.

The projectiles are canister and shell. The canister is a cylinderical tin case having a bottom and cover. It is charged with 30 hardened lead, one ounce, bullets held in position by sulphur cast in the interstices.

The shell is the ordinary cylindro-ogival pattern, with a nose fuse.

The gun is fired by means of the ordinary friction primer.

The carriage is of the ordinary type of mountain carriages, but is made of steel.

This gun was designed to satisfy the following conditions, viz:

(1) To produce a gun that could follow infantry into any position they might have to occupy. To make the parts sufficiently light so any one of them could be transported on wheels, pack animals, or by hand.

(2) To reduce the weight of projectiles so as to permit of the transportation of a relatively large number of rounds, with a minimum number of men and pack animals.

(3) To compensate for the small mass of the projectiles by an increase of initial velocity and ballistic density, in order to insure an effective power at all fighting distances.

(4) To simplify the mechanism, the manipulation, and the maintenance of the piece in serviceable condition, so that infantry or volunteer troops could handle it without long instruction or the assistance of technical troops.

Principal dimensions, weight, etc.

	Metric.	English.
Gun, total length	1.170 meters	46 inches.
length of bore (25 calibers)	1.065 meters	
diameter of bore	42 millimeters	1.65 inches.
weight of piece	55 kilograms	121 pounds.
Ammunition, cast-iron shell, weight	880 grains	1.9 pounds.
bursting charge	50 grains	1.8 ounces.
canister, weight	1.280 grains	2.8 pounds.
number of balls	30	30.
powder charge	175 grains	6.17 ounces.
weight of cartridge with shell	1.210 kilograms	2.7 pounds.
canister	1.612 kilograms	3.5 pounds.
total length of cartridge	263 millimeters	10.34 inches.
initial velocity	425 meters	1,394.3 feet.
Carriage and harness, weight of carriage	100 kilograms	220.46 pounds.
diameter of wheels	950 millimeters	37.40 inches.
Width of tread	750 millimeters	29.52 inches.
height of center of trunnions	710 millimeters	27.95 inches.
weight of 2 ammunition boxes, full	122 kilograms	268.95 pounds.
number of rounds per box	42	42.
weight of pack-saddle, for gun mule	28 kilograms	61.73 pounds.
weight of pack-saddle, for carriage mule	29 kilograms	63.93 pounds.
weight of pack-saddle and harness for ammunition mule	23 kilograms	50.71 pounds.

42-MILLIMETER YACHT GUN WITH ITS SPECIAL CARRIAGE; (2-POUNDER; CALIBER, 1.65").

(Plate XXI.)

This gun is specially designed for yacht service, and is not only elegant in appearance but furnishes a practical armament. Its ship carriage rests on a chassis of three parallel tubes held together by a front transom carrying the lunette for the pivot pin, and a rear transom carrying friction rollers which traverse upon a bronze circle fastened to the deck. The top carriage of ordinary form is supplied with an automatic friction brake acting on the middle tube of the chassis.

The elevating apparatus is controlled by a screw.

The chassis is traversed by rope and tackle, which serve to moor it when not in use.

Principal dimensions, weight, etc.

	Metric.	English
Weight of gun	55 kilograms	121 pounds.
projectile	880 grains	1.9 pounds.
carriage	102 kilograms	224.87 pounds.
Length of carriage	1.290 meters	50.78 inches.
Recoil of gun upon carriage	350 millimeters	13.78 inches.
Height of center of trunnions above deck	420 millimeters	16.54 inches.
Limiting angles of fire, elevation	+ 15 degrees	+15 degrees.
depression	— 10 degrees	—10 degrees.
Initial velocity of projectile	425 meter	1,394.4 feet.

AMMUNITION FOR RAPID-FIRING GUNS.

CARTRIDGE CASES.

(Plates XXII and XXIII.)

Two kinds of cartridge cases are made, viz: (1) "solid drawn," (2) "made-up," depending on the method of construction of the head. In the first class the head is part of the body, the whole being formed from one piece of metal. In the second class the head is partly made from separate parts. The latter has always been the standard ammunition for the revolving cannon. The former is the latest development from small-arm ammunition.

Made-up case.—The body is a brass tube drawn to shape and "necked" (narrowed down) at mouth to the diameter of the projectile. The base is turned and reënforced by two brass cups—one inside and one outside of the incurved part. A sheet-iron disk forms the extreme outside base and has a projecting rim for extraction. The whole is riveted together, forming a gas-tight head.

A small brass cup, with a bottom pierced and shaped to form an anvil and fitted with a percussion cap, constitutes the primer.

Solid-drawn case.—The solid-drawn cases are often made of extra strength and thickness to permit of reloading half a dozen times without resizing, which is claimed as an advantage. This advantage is *nil* for field service. The waste of cases in service from loss, carelessness, and accidental deformation is necessarily great. Empty cases have to be gathered up and stored until time is secured for cleaning, gauging, and assorting. Those for resizing must be sent to an arsenal or depot to be prepared for reissue.

The first cost is more important than the quality of reloading. The solid drawn case is more expensive, and for a single round no better.

The faults developed in the fabrication of these large cases are given above, under the 65-millimeter gun.

SHELLS.

(Plate XXIV.)

All Hotchkiss shells, except the cast-iron ones, which are used for revolving cannon ammunition, have solid heads and carry the fuse in the base.

There are two kinds of shell, cast-iron and steel.

Common shell.—This is single cast-iron casting, with a blunt point by which it may always be recognized.

Steel shell.—This shell is sharp pointed, is made in two parts, and tempered for armor-piercing. The base is the full diameter of the shell cavity and is screwed in. Its front end is cup-shaped, to form a sort of gas check to expand against the walls of the shell and hold until thorough fracture is determined by the explosion of the bursting charge. Were the shell made in one piece there would be a surface of weakness between the cylindrical walls and base of the shell, and the latter would be blown out without fracture of the walls taking place. (For examples of fractures see Plate XXVII.)

Both shells have the usual cylindro-ogival form. The common shell is not chill-cast. The steel shell is "highly tempered throughout."

The rotating bands are brass, and the projectiles have a slight swell at the junction of the head and body for centering them.

CANISTER OR CASE SHOT.

(Plate XXIV.)

The body of these projectiles is a thin sheet brass case, with a conical head and a gas-check bottom of soft metal to give rotation. A sheet-iron plate in the inside strengthens the bottom. The interior is filled with hardened lead balls, with sawdust in the interstices.

There are fifty balls in the 3-pounder (47-millimeter) and eighty in the 6-pounder (57-millimeter) canister.

SHRAPNEL.

(Plate XXIV.)

The exterior comprises three pieces besides the fuse—the head, the body, and the base.

The body is a section of steel tube weakened longitudinally by 6 grooves to facilitate fracture. The upper end is crimped into a recess in the brass head.

The ogival head is solid and is fitted for the nose fuse.

The base is a steel disk forced in by pressure and retained by friction. The body is filled with bullets arranged symmetrically in layers. In calibers above the 3-pounder (47-millimeter) the layers are held apart and the bullets retained in position by small disks of cast iron, so designed as to give six fragments in the 6-pounder and a proportionally large number in the higher calibers. The bursting charge of powder is held in a small tin cup inserted in the front end of the body. This arrangement of charge and fracture lines increases the density of the cone of dispersion. The bursting charge is relatively large, to give a maximum of smoke as a range indicator.

The shrapnel is armed with an Armstrong combination time and percussion fuse, whose maximum time of burning is 8 seconds, corresponding to a range of about 3,100 yards.

The explosion of a 6-pounder shrapnel gives the following results, viz:

	Number of pieces.
Fuse	2
Head, base, rifling band, and powder cup	4
Body	12
Bullets	40
Cast-iron separators	42
Total	100

FUSES.

Four types of fuses are employed with Hotchkiss ammunition, viz:

(1) Hotchkiss (nose) fuse, used only with revolving cannon ammunition.

(2) Hotchkiss base fuse, used with all other shells.

(3) Armstrong combination time and percussion fuse, used with shrapnels.

(4) Desmarest fuse, used with revolving cannon ammunition.

THE HOTCHKISS POINT FUSE.

(Plate XXV.)

The Hotchkiss fuse, or Hotchkiss nose fuse as it is generally called now to distinguish it from the Hotchkiss base fuse, is composed of the following principal parts: (1) The body; (2) the plunger; (3) the head, and (4) the safety plug.

The body is cylindrical, with exterior screw thread and a shoulder at upper end to secure it in the shell. The profile is made to conform to the ogival form of the projectile.

A chamber is cut in the body, with a conical hole for the safety plug at the lower end.

The plunger is a hollow cylinder whose weight is increased by a lead lining; it contains a small chamber filled with powder, with a percussion cap over it, and the whole covered by foil to protect it from moisture.

A brass wire is inserted in the lower part of the plunger and so bent that the ends project through the conical plug hole.

The above parts are made of brass.

A lead stopper is forced strongly into the conical hole in the base of the fuse, wedging the ends of the brass wire and holding the plunger steady; this forms the safety plug.

The head is gun metal, with an exterior ogival profile and a screw thread to fasten it to the body. A steel point or firing pin is fixed in the center of the under side for detonating the fulminate when the latter comes in contact with it.

Action of fuse.—The shell is fired; the inertia of the plunger carries it to the rear, forcing the safety plug back into the shell, opening communication between the fuse and powder charge.

The small wires keep the plunger from rotating independently of the shell and prevents its falling forward in the falling branch of the trajectory. On impact the plunger is impelled forward and the igniting charge is fired by the detonation of the primer which comes in contact with the steel point.

The Hotchkiss base fuse.

(Plate xxv.)

This fuse consists of three main parts—body, plunger, and detonating cap.

The body is made of gun metal, threaded on the exterior, with a wide shoulder beveled to a thin edge to form a gas check.

The plunger is a body of lead cast in a cylindrical case of brass supporting axially a wire roughened so as to hold the lead. The rear end of the wire projects out of the plunger, while the front end, sharpened to form the firing pin, remains below the front surface in a small cavity in the mass of lead.

The detonating cap is a small brass cap filled with fulminate, screwed into the front end of the body.

Action.—When the gun is fired the powder pressure on the head seals it gas tight; the plunger flies to the rear along the wire, upsetting the lead and gripping the wire. On impact the plunger moves forward under the influence of the shock, and the projecting point

of the firing-pin pierces the cap and explodes the fulminate; the blast escaping through a vent in the top into the shell ignites the powder charge.

The Armstrong combination time and percussion fuse.

(Plate xxv.)

This comprises the body, time disk, cap, plungers, needles, time circuit, and magazines.

The material composing the body is an alloy of lead and tin with a little antimony. The lower part of the body is threaded on the exterior to screw into the shell and chambered to hold the percussion arrangement. The middle part has a larger diameter, with an annular groove on the upper side to hold the incendiary composition forming the time circuit, and is graduated on the exterior circumference into inches and tenths. The upper part is of smaller diameter than the others and is hollowed out to contain the time circuit and igniting device, and has its upper end threaded exteriorally to receive the cap. The percussion arrangement is similar to that of the nose fuse. The firing pin is set point downward just over a small magazine of fine powder, with a fulminate cap on top. These are held in metallic rings and form the plunger. In firing, the magazine is driven back to the bottom of the fuse and on impact springs forward against the firing pin and is exploded.

Over the upper tenon of the body a loose disk is placed containing a ring of mealed powder, which connects the upper percussion arrangement with any desired portion of the time circuit. The disk is held in any required position by screwing down the brass cap, which also holds the plunger for the upper percussion apparatus. This plunger is suspended over the firing pin by a light copper cup whose projecting arms rest on top of the body of the fuse. When the gun is fired, the top plunger is forced down on the firing pin and its fulminate exploded, igniting the circuit of mealed powder in the loose disk and then the point of the time circuit at which the disk was set. This circuit burns to the end and communicates with the lower magazine and shell-charge by means of a column of mealed powder.

The Desmarest point fuse.

(Plate xxv.)

This percussion fuse has a gun-metal body which screws into the shell. The shoulder is ogival in form. A percussion cap, mouth down, is placed in the base of the chamber and corresponds in position to the safety plug in ordinary fuses. A wooden plunger armed with an iron firing pin is inserted tightly in the open nose of the fuse and held by brass suspending wires. The nose is made water-tight

by putty. The suspending wires have sufficient strength to hold the light wooden plunger against the shock of discharge. In firing, the plunger is driven down by striking an obstacle and explodes the cap which communicates with the charge.

As the fuse acts by direct impact it is unreliable on graze.

THE DRILL CARTRIDGE.

(Plate XXIII.)

The persistent drill of the gunners is absolutely necessary to develop the full efficiency of rapid-firing guns, and it must be assimilated as closely as possible to actual service conditions. The cost of ammunition and the limited supply furnished war vessels does not admit of the use of service ammunition in drill.

To remedy the difficulty and to supply a means for actual firing at small cost the "drill cartridge," using small-arm ammunition, has been devised.

This device consists of—

(1) A length of service rifle barrel forming the core of the complete cartridge and having a proper chamber for the small-arm cartridge fitted in the rear end.

(2) A body of vulcanized rubber, with a brass head or point, made up to the exact profile and weight of the loaded cartridge pertaining to the caliber for which the device is made.

(3) A steel base, with a lip for extraction.

This "dummy cartridge," as it is called, corresponds in all respects with the service cartridge. To load it a small-arm cartridge is simply inserted in the chamber, where it is held by a spring catch.

The ordinary service of the gun is employed in practice with the ammunition, but the rear sight must be marked for the small-arm cartridges. Target practice up to 1,200 yards, the active fighting range of rapid-firing guns in naval service, is as thorough and accurate as with service ammunition.

A box of twenty "dummies" is sufficient for a ship, as they may be reloaded in a few seconds.

HOTCHKISS PRACTICE TUBE FOR FIELD AND SIEGE GUNS.

This tube is designed for practice firing and instruction in pointing and using field, siege, and position guns.

It consists of a 37-millimeter (1.4567 inches) tube of the Hotchkiss revolving cannon furnished with centering disks to keep its axis concentric with that of the piece for which it is intended.

With it all the actual operations of firing in action can be reproduced at trifling expense and on restricted firing grounds.

This tube is so adjusted in the bore that the breech mechanism of the piece itself closes the tube in rear. The ordinary shell weighs

480 grams (16.90 ounces). The powder charges, about 8 grams (0.282 ounce) for field firing and 2.5 grams (0.088 ounce) for plunging fire, impress, respectively, upon the projectile initial velocities of 170 and 75 meters (557.75 and 246.066 feet per second). The latter corresponds to a range of 200 meters (218.7 yards), under an angle of fire of 11 to 12 degrees.

This powder charge is inclosed in the ordinary center-primed hunting shell, which is placed in the false chamber of the practice tube.

The charge is ignited by a blow from a percussion lock actuated by a lanyard.

A drill cartridge is made for practice firing with the Hotchkiss rapid-firing guns, employing the ordinary small-arm ammunition.

THE HOTCHKISS WARNING INCLOSURE FOR VESSELS, ETC.

(Plate XXVI.)

The object of this invention is to protect navy vessels, anchorages, and open roadsteads during the night or in foggy weather against the attacks of torpedo boats or other floating means of offense.

This girdle or inclosure consists of several lengths of wire, rope, or cord, the strands of which are bound together or twisted, and to which cork floats are fastened that sustain it a little below the surface of the water.

At the junctions of the several lengths, by means of anchor rings, are fixed buoys solidly moored to the bottom. The buoys serve to preserve the form and position of the inclosure; they also regulate and preserve its buoyancy.

The buoys contain inflammable ingredients, which render them luminous when any portion of the girdle is unduly strained by the shock of the attacking object. They also inclose detachable floats, which are fixed to the ends of the wire cord and contain inflammable material which ignites when the floats are separated from their mooring buoy.

If a vessel be protected by one of these inclosures, and a torpedo boat attempts to attack her, in so doing the torpedo boat carries away the length of wire rope between two adjacent buoys and a float from each.

The shock which tears the floats away from their moorings also brings the calcium phosphide in each of them, as well as in the buoys in contact with the water, and the four contrivances become luminous.

The two buoy lights indicate the points between which the torpedo boat entered the inclosure. The two floating lights buoyed by the cork and towed by the assailant mark its position and motion sufficiently to guide the vessel in its effort to repel the aggressor.

CHAPTER IV.

FIRMINY STEEL COMPANY. (Loire.)

LOCATION AND PRODUCTS.

This company, whose works are located in the basin of the Loire, possesses a number of special processes that account for its high reputation as manufacturers and its financial success.

The company exhibits a great variety of products, but by no means a complete list of its fabrications.

Among the raw products is a series of samples of cast iron of great variety, ranging from common cast iron to refined spiegeleisen with 15 per cent of manganese, chrome cast iron with 25 per cent of chromium, silico-spiegeleisen with 15 per cent silicon and 18 per cent manganese. These are all produced in one blast furnace with a capacity of 200 cubic meters. The output per day of 24 hours is from 120 tons for common pig to 10 tons for silico-spiegeleisen.

The Firminy Company also makes cast-iron by means of the Rollet cupola furnace. Specimens shown of this pig iron are said to contain only .004 per cent of phosphorus and a trace of sulphur. It is from this pig that the company makes its high class steel for ordnance projectiles, tools, etc.

The total output of cast steel from the works has increased in 5 years from 150 to 200 tons per year to 1,000 tons per year. It is claimed that the Firminy steel never falls short of the following figures: Elastic limit, 19 tons per square inch; ultimate strength, 38 tons per square inch; elongation, 8 to 22 per cent, depending on nature of test bar.

Steel castings are made for gun carriages, and are shown in the exhibit of the Forges et Chantiers de la Médéteranée in the carriages for the following guns, viz: 27-centimeter gun, length 30 calibers; 27-centimeter gun, length 36 calibers; 32-centimeter gun, length 38 calibers; carriages for rapid-firing guns of from 10 to 14 centimeters.

Another specialty is steel wire of very high resistance, for cables, wire guns, etc. The wire for the experimental Schultz gun, constructed by the Fives-Lille Company, was made by this company. This wire, 3 millimeters in diameter, gave a resistance to rupture of 133 tons per square inch, and sustained twelve alternating bends almost at right angles before rupturing.

In the company's exhibit an 1800-pound projectile is suspended point down from a piece of this wire 2.7 millimeters (0.1 inch) in diame-

ter and attracted much attention. The breaking weight of the wire is 13.3 tons, or 135 tons per square inch. The wire, 0.08 inch in diameter, has a breaking weight of 1,716 pounds, or 158.75 tons per square inch. The strength of the commercial examples of steel wire for cables varies from 47.6 to 114.28 tons per square inch.

Another specialty is the manufacture of coppered wire covered with nickel, for furniture springs. Piano wire and telegraph wire are also made of high quality.

The exhibit of samples of crucible steel is especially interesting. The samples were divided into classes depending on the purity of the raw materials employed, each class having a series of numbers varying with the degrees of hardness due to the proportion of carbon, chromium, or tungsten entering into the composition. Each sample bar had a label stating the principal uses for which it was adapted, data concerning the manufacture, and the degree of temper required. The fractured specimens were shown in an adjacent glass case, and were full of interest and instruction. The chrome and tungsten steel were especially remarkable for their fine grain and silky texture.

Examples of the Verdié process of combining steel and iron for dies, shears, and other cutting tools were shown. In this process the steel face is cast on the wrought-iron body wherever desired; the fractures of the bars, tempered and untempered, so made, show a perfect union between the two metals.

Puddled iron on the Rollet system, Martin-Siemens steel, and especially the chrome steel for tools and cutters, also deserve mention to show the wide range of this company's fabrications. Large quantities of the material (Martin-Siemens steel) for the Lebel rifle are supplied to the French Government; special qualities of homogeneity and tenacity are claimed for the Lebel barrels.

One of the most recent industries of this firm is the fabrication of compressed-air reservoirs for locomobile torpedoes. A specimen exhibited, known as size No. 5.75, has the following dimensions:

Length	inches	88.5
Diameter	do	15.0
Thickness	do	0.256
Weight	pounds	292

The tests applied require a very high elastic limit and the manufacture demands the greatest care. The insertion of the ends is a test of manipulative skill to make them tight under a pressure of 1,850 pounds per square inch, which represents a total pressure of about 125 tons on each end.

The production of Siemens-Martin open-hearth steel has for years been one of the most important parts of the industry of the Firminy works.

At first the manufacture was confined solely to the production of field guns, but since the national wants have been pretty well sup-

plied in that respect and steel has been adopted for large calibers, the plant has been increased until now the capacity is sufficient to handle guns up to 13 meters (42 feet 7 inches) in length.

This company was among the first to make shells from crucible cast steel, forged and tempered. It has been very successful with these projectiles.

STATISTICS OF PRODUCTION OF WAR MATERIAL BETWEEN 1870 AND JUNE 30, 1889 (SOCIÉTÉ DE FIRMINY).

(1) FOR WAR DEPARTMENT.

Thirty-seven guns of 7 centimeters (2.75 inches), system Reffye, completely finished.

	Metric.	English.
	mm.	*Inches.*
260 tubes and 200 coils for mountain gun of	80	3.15
130 tubes and 20 coils for field guns of	80	3.15
720 tubes and 3,430 coils for field guns of	90	3.54
60 tubes and 1,040 coils for field guns of	95	3.74
485 tubes and 7,050 coils for field guns of	120	4.72
87 tubes and 768 coils for long guns of	155	6.10
42 tubes and 606 coils for short guns of	155	6.10
6 tubes and 606 coils for guns of	190	7.48
41 tubes and 272 coils for guns of	220	8.66
8 tubes and 254 coils for guns of	240	9.45
20 tubes and 360 coils for guns of	270	10.63

(2) FOR NAVY DEPARTMENT.

	Metric.	English.
	cm.	*Inches.*
41 gun bodies, 10 tubes, and 200 coils for guns of	14	5.51
5 gun bodies, 5 tubes, 5 rings, and 65 coils for guns of	16	6.30
5 gun bodies, 3 tubes, 3 rings for guns of	24	9.45
5 gun bodies and 10 coils for guns of	27	10.63
6 tubes and 12 coils for rapid-firing guns of	10	3.93
5 tubes for rapid-firing guns of	14	5.51

(3) MISCELLANEOUS.

	Metric.	English.
	cm.	*Inches.*
44 mortars for Italy of	15	5.9
28 tubes and 28 outer coils (Italy) for guns of	15	5.9
6 tubes and 21 outer coils (Greek cruisers) for guns of	15	5.9
8 outer coils and 16 coils (Greek cruisers) for guns of	9	3.54
	mm.	
18 coils (Greek cruisers) for guns of	47	1.85
24 coils (Greek cruisers) for guns of	57	2.24

(4) FORGED AND TEMPERED STEEL SHELLS.

	Metric.	English.
	mm.	*Inches.*
50 shells for land artillery, caliber	90	3.54
10 shells for land artillery, caliber	95	3.74
150 shells for land artillery, caliber	155	6.10
100 shells for land artillery, caliber	120	4.72
	cm.	
250 shells for marine artillery, caliber	24	9.45
282 shells for marine artillery, caliber	27	10.63
519 shells for marine artillery, caliber	34	13.38
15 shells for marine artillery, caliber	37	14.57
127 shells for marine artillery, caliber	42	16.54
26 shells for marine artillery, caliber	30	11.81
	mm.	
156 shells for forges et chantiers, caliber	57	2.24
	cm.	
42 shells for forges et chantiers, caliber	12	4.72
20 shells for forges et chantiers, caliber	16	6.30
160 shells for Spanish navy, caliber	24	9.45
96 shells for Spanish navy, caliber	28	11.02
90 shells for Spanish navy, caliber	32	12.60
10 shells for English navy, caliber		3.00
250 shells for English navy, caliber		9.00
250 shells for English navy, caliber		12.00

Total, 2,603 steel shells.

CHAPTER V.

THE WORKS OF CHATILLON & COMMENTRY.

(Compagnie Anonyme des Forges de Chatillon et Commentry.)

This company was founded in 1845 and reorganized under its present form in 1862. It controls the following establishments:

WORKS.

(1) Blast furnaces, iron and steel, and artillery works at Montluçon, St. Jacques (Allier).

(2) Blast furnaces and works at Commentry (Allier).

(3) Blast furnaces at Beaucaire (Gard).

(4) Blast furnaces at Villerupt (Meurthe and Moselle).

(5) Iron works, wire mills, and nail works at Sainte-Colombe, Ampilly, Missy, and Chamesson (Côte d'Or).

(6) Iron and wire works at Plaines (Aube).

(7) Wire and cable works at Trouçais (Allier).

(8) Wire works for special products at Morat (Allier).

(9) Wire works and nail works at Vierzon (Cher).

MINES.

(1) Of Cher.

(2) Of Indre.

(3) Of Villerupt (Meurthe and Moselle).

(4) Of Butte (Alsace-Lorraine).

COAL MINES.

Name and location of mine.	Annual production of coal.
	Tons.
(1) Bezenet } In Allier	160,000
(2) Doyet } In Allier	50,000
(3) Les Ferrières } In Allier	50,000
(4) St. Eloi (Puy de Dôme)	150,000
Total annual output	410,000

The development of the company's steel works, which produce steel by the Bessemer, Siemens acid, Siemens basic, and crucible processes, has given a great impetus to its production of steel cables and wire of all kinds.

The number and classification of the varieties and forms of iron, sheet metals, etc., are too numerous to mention.

STEEL CASTINGS.

The progress in the art of steel casting has been so great in the last few years that these castings are being substituted largely (1) for pieces in cast iron; (2) for pieces in wrought iron, and even (3) for pieces in forged steel.

With proper care, steel castings are now made almost as easily as cast-iron castings. The most delicate castings leave the mold as clean and sound as pieces of bronze.

The advantages of the substitution of cast steel for cast iron and forged metals are considerable:

(1) The steel being three to four times stronger than cast iron, the dimensions and weights of the parts of machines, of engines, etc., formerly made of cast-iron, may be appreciably reduced, at the same time securing greater solidity.

(2) The prices of forged pieces are very high. The price of steel castings is less, and they have the advantage of diminishing the work of finishing and lending themselves to the most complicated forms.

This company can cast steel tubes without blow-holes, 4 meters (13.12 feet) long, 30 centimeters (11.8 inches) in diameter, and 20 to 25 millimeters (0.79 to 0.98 inch) in thickness.

The traction test of specimens from the current work give: Ultimate resistance, 50 to 54 kilograms per square millimeter (71,115 to 76,805 pounds per square inch); elongation, 10 to 15 per cent.

Besides large numbers of steel castings made for railways, mines, naval construction, agricultural implements, mechanical constructions, and other diverse uses, many are made for artillery carriages and for the purposes of military engineers.

The pieces molded for military material have always given good results in the trials and resist well the violent shocks developed in gun carriages at the instant of firing.

CRUCIBLE STEEL.

The three principal methods of making steel are:

(1) By converters (Bessemer or other).

(2) By Siemens furnace.

(3) By crucibles.

The converter is a rapid and economical method of producing large masses of steel which is imperfectly refined and whose ingredients can not be definitely regulated in quantity. The Siemens furnace produces steels more regular in their composition and pure enough for the major part of uses; but it is to the crucible that one has recourse when it is desired to prepare in small quantities steel of a rigorous composition, presenting the varied and remarkable qualities demanded for the preparation of tools for use in every

variety of industrial service—drills, turning tools, graving tools, boring bits, punches, dies, saw blades, etc. Tool steel has generally been the specialty of a few works where the formulas of fabrication were learned from long practice and were transmitted hereditarily. Now, thanks to the progress of metallurgy, the composition and conditions of fabrication of steel for the tool destined for each kind of work may be defired with precision. The extreme care required and the high quality demanded in this class of steel and the small quantity operated upon will always keep the price of crucible steel higher than that of any other variety. Still, it is no longer the monopoly of any one or two firms.

This company fabricates not only tool steel by the crucible process, but has extended the use of its crucible steel to the fabrication of projectiles for piercing armor plate of hard metal (steel or compound plates). The company makes a specialty of steel projectiles for perforating or rupturing, forged from crucible chrome steel. These shell pass through, without appreciable deformation, steel plates of the highest resistance and of a thickness superior to their caliber.

There was exhibited a series of these steel projectiles, forged and tempered, comprising: Two shell, 34 centimeters; two shell, 10 centimeters; two shell, 155 millimeters, cylindrical; two shell, 155 millimeters, Bussière; two shell, 27 centimeters, large cavity; one shell, 22 centimeters, small cavity; two shell, 27 centimeters, small cavity. Besides the above is shown a large series of fractures of shell. The company also fabricate projectiles of all calibers from chilled cast iron and cast steel. It has furnished 70,000 projectiles of all kinds since 1875, and, in addition, from 1880 to 1885, it delivered to the French Government 200,000 Hotchkiss shell.

TUBES AND HOOPS FOR CANNON.

These are made from puddled steel, forged and tempered, and regularly fulfill the rigorous conditions imposed by the French land and marine artillery.

ARMOR PLATES.

One of the great specialties of this company is the production of armor plates for naval vessels and for armored land defenses.

NATURE OF THE METALS.

(1) *Wrought iron or compound metal.*—The armor plates furnished to the French navy until this year (1889) have been of wrought iron or compound metal (*i. e.*, wrought iron faced with steel). The tonnage of the wrought iron plates delivered exceeds 14,000,000 kilograms (30,864,000 pounds = 13,800 tons); that of compound plates, 7,000,000 kilograms (or 15,432,000 pounds = 6,900 tons).

(2) *Chilled cast iron.*—The company supplied twenty-one of the twenty-five armored turrets furnished the French Government in 1876.

(3) *Laminated steel.*—The steel destined for armor is classified by the company in two categories of two kinds each, viz: Laminated steel—first category: (1) Extra-soft steel or métal St. Jacques; (2) soft steel. Second category: (1) Half-hard steel; (2) hard steel.

The variety of extra-soft steel has a resistance superior, with a malleability at least equal, to wrought iron.

In addition it possesses a homogeneity that can not be obtained in a puddled metal. It is advantageously used to replace wrought iron in applications where malleability is specially required, viz: For the deck plates of vessels exposed to an oblique fire, and for all plates strongly curved. At the Polygon of Gâvres this metal has been subjected to normal and oblique fire and gave results quite superior to plates of puddled iron.

The deck armor of the *Suchet* and the *Alger* (both French vessels) are made of this metal, and the proof trials for the receipt of the plates has borne out the previous results.

This metal is also suited to the armoring of the domed turrets or cupolas for land defenses. The Belgian Government intends to have made by this company, from this steel, thirty-two cupolas out of the sixty-three large cupolas for one and for two 12-centimeter (4.72 inches) guns designed for the defense of the valley of the Meuse.

The resistance to perforation, as determined by numerous comparative trials with wrought iron, is 1.19, that of iron being taken as unity.

Soft steel.—This variety is a little less malleable than the above. Its resistance is 1.25 that of iron taken as unity.

This steel is malleable enough to support without difficulty, for all thicknesses of plates, the changes of form and deformations imposed by the model of an armored vessel.

Half-hard steel.—This steel presents a resistance to perforation of 1.30 by comparison with wrought iron of equal thickness. It can be forged almost as easily as the soft steel.

Hard steel.—This variety presents a resistance of 1.35 as compared with wrought iron. It is particularly prepared for making shields for gun carriages. It will permit modeling to the forms of vessels with more facility than the ordinary chrome metal, and can be made in thicknesses of from 40 to 50 millimeters (1.57 to 1.97 inches) and above, and be applied directly to the sides of vessels or for covering the decks or certain parts of the armored belts of navy vessels.

The plates made of the hard or half-hard steel present, with less weight, an increase of resistance over wrought-iron plates, or even forged-steel plates, which marks a substantial progress in armor. These two varieties of steel have been adopted by Greece for the armor of its light vessels now building in France.

ARMOR.

Among the many armor plates exhibited by this company was a wrought-iron plate 50 centimeters (19.7 inches) thick, which had been subjected to fifty-five shots from a 270-millimeter (10.63 inches) gun, and a deck plate 80 millimeters (3.15 inches) thick of soft steel, which had been subjected to oblique fire with 270-millimeter (10.63 inches) shells and direct fire with 100-millimeter (3.94 inches) projectiles, both of which were extremely interesting. Besides the numerous armor-plate exhibits there were projectiles in chilled cast iron, cast and forged steel of all calibers, tubes for guns, and frettes of puddled or cast steel; wire cables of all kinds; series of bar steel of all kinds and composition, with fractured specimens of the same, and large steel castings for gun carriages.

TEMPERING PLATES.

The tempering in water and in oil often cause in the metal irregular interior tensions which result, even after putting the plates in position, in cracks. The company has patented a process for tempering in melted lead, which is said to give better results.

ROLLING MILL.

The works at St. Jacques possess the most powerful plate roller in France. Each roll weighs 30 tons, and is 4 meters (13.12 feet) long. The distance between the rolls can take an ingot 1.80 meters (5.9 feet) in thickness. It produces plates 0.60 meter (1.97 feet) thick, 3.20 meters (10.5 feet) wide, and weighing 40 tons.

The company is adding to its plant a press of 4,000 tons for forging and forming armor plate. This tool will give more satisfactory and rapid results than powerful steam hammers.

CHAPTER VI.

WORKS OF ST. CHAMMOND.

(Compagnie des Hauts-Fourneaux, Forges et Aciéries de la Marine et des Chemins de Fer.)

LOCATION OF WORKS.

This company, whose corporate French title is given above, though it is generally known simply as St. Chamond, has its principal seat of operations in the basin of Loire.

In this region will be found its factories and metallurgical establishments of St. Chamond, its rolling-mills and steel works of Assailly, its forges of Rive-de-Gier, and its blast furnaces and steel works of Givors.

In the south, near Bayonne, will be found its blast furnaces, steel works, and forges of the Adour (Boucau).

In Corsica are its old charcoal blast furnaces of Toga, from which it obtains the charcoal pig iron used in the fabrication of armor plates, and steel hoops for cannon.

The charcoal for Toga is obtained from forests owned in Sardinia, and it also possesses iron mines at St. Leon, Sardinia, which supply a magnetic iron ore said to be equal to the best Swedish ores. The company also has coal mines in the basin of the Loire.

The fabrication of artillery *matériel* is concentrated at St. Chamond. The company has organized a special technical service for this branch of its works, and is prepared to deliver everything connected with the artillery armament of the land and naval services in complete readiness for use.

WAR MATERIAL.

It will be convenient to divide the various productions of the company under this head into three classes.

(1) The fabrication of artillery, field, siege, place or garrison, seacoast, and naval guns, with their carriages, munitions, and accessories.

(2) The execution of works pertaining to permanent fortifications.

(3) The fabrication of armor plate for naval vessels.

(1) Fabrication of artillery material.

Tubes and hoops.—The tubes or gun bodies are made from steel ingots cast at St. Chamond. The cast-iron used in the fabrication

of the ingots is furnished by Gions and Boucau and the iron by St. Chamond itself. The pig iron from Gions is made from the magnetic oxide of Sardinia mixed with chosen ores from Spain and Algeria That from the Adour is exclusively made from selected ores from Bilboa and Bidassoa. These pig irons are made with coke, but contain only traces of impurities: "Sulphur, about two ten-thousandths; phosphorus, about five ten-thousandths."

The cast-iron employed in the steel furnaces is still purer; it comes from the above by a special process of refining, patented by the company, and is specially used for the fabrication of guns and crucible steels.

These refined cast irons contain: "Sulphur, about one ten-thousandth; phosphorus, often less than one ten-thousandth."

The company claims that these refined cast irons are purer than the most renowned Swedish irons.

The steel ingots are made in the Martin-Siemens furnace, the plant being sufficient to readily handle 100-ton ingots.

The furnace charges are from the above refined irons, to which are added in the furnaces puddled iron from similar pig.

The casting is done with special care as to the temperature of the bath, the time of filling the mold, and the choice of dimensions of the latter.

The forging is done rapidly, since the plant is prepared to handle ingots quickly and the arrangements for heating are good. The power-hammers vary from 10 to 100 tons, depending on the size of the ingot and intensity of blow required. Special dispositions are made for annealing immediately after forging.

The plant for tempering and annealing tubes, etc., are grouped in the same shop to secure continuity of operations without loss of time or increased expense of transport. The installation for heating and tempering long tubes for cannon comprises a furnace 21 meters in height (68.9′) and a tempering pit of equal depth.

A collection of three large tempering tanks connected with each other permit the use for one operation of about 200 cubic meters of oil.

A 50-ton traveling crane or bridge, with a double steam and hydraulic motion, handles the large pieces in tempering and permits a velocity of immersion of more than 30 meters (98.4′) in a minute.

Large shops, in close proximity to the shops for forging, tempering, and annealing, furnish the machinery for turning, boring, and finishing guns as well as for cutting out test specimens for the numerous trials made for each piece in course of fabrication.

The company use the general specifications adopted by the French artillery for these tests.

General conditions of fabrication.—The average cross section of the cast ingot is, at a minimum, four times greater than that of the

rough forging before turning, and the weight of the forged piece must not exceed 50 per cent that of the ingot employed.

The metal has, before tempering, a resistance of 40 to 60 kilograms (25.4 to 38 tons per square inch) and 18 per cent elongation at the minimum; after tempering, a resistance of 54 to 80 kilograms (34.3 to 51 tons per square inch), and an elongation of 12 to 14 per cent at a minimum.

These tests are made on specimens cut from disks detached from the breech and muzzle after tempering and after annealing.

The proof of the finished piece is made with extra charges on the proving grounds of the company.

The various stages of the work are followed throughout with the most minute care.

All pig designed for gun work is analyzed before using and is subjected to special treatment; the iron thus refined is again classified, and admitted or rejected depending on the results of a rigorous chemical analysis.

After casting, the metal in the ingot is tested by impact and traction, and analyzed. After once forging it is again tested at each step of fabrication, and the test specimens are analyzed as a check on the previous results.

The hoops for field guns are of cast or puddled steel; in the latter case the puddling is done at St. Chamond, using charcoal pig made at Toga (Corsica) specially for this purpose.

The rough bars are subjected to a rigid assorting based on the grain of the steel.

The hoops are made without welding, carefully forged, rolled, and tempered. Each lot is tested for elasticity, resistance, and bending. The hoops for navy guns are almost all made of cast steel. In this case the ingots are treated as before,the only difference being in the degree of hardness required.

These navy hoops are finished by hammering, boring, and planing, with tempering and annealing same as for the tube. A cold mandreling test for extension is applied to each cast-steel hoop. The preliminary tests in the mass must be satisfactory before the other operations are begun.

The armor piercing shells or projectiles are a specialty of the company. They are made of extra hard crucible steels, strongly hammered, and then tempered and annealed by special processes peculiar to the company. The quality is deservedly high in rank.

All kinds of gun and battery carriages are made with their accessories.

(2) THE EXECUTION OF WORK PERTAINING TO PERMANENT FORTIFICATIONS.

This bureau is under the direction of Commandant of Engineers Mougin, who was formerly chef de service of armored constructions

in the War Department. The company furnished armor for the French forts and have made two types of armored turret. One type for two 155 millimeters (6.1 inches) guns, for the Roumanian Government. The original Bucharest trial turret had cylindrical walls, if the writer's memory be correct, which were afterwards modified to a domed form. The other type is the one furnished the French Government for trial at Chalons.

In this connection the personal experience of the company resulted in the belief that wrought-iron armor is better than harder or more brittle metals, for permanent fortifications. A special study has been made of carriages of position, etc.

(3) Armor plates for navy vessels.

This is the first company in Europe which undertook the fabrication of plates for navy vessels, over 30 years ago.

The plant is installed for making wrought iron, compound, or steel plates. The principal work heretofore done has been in wrought iron and compound plates. For wrought iron, and the backing of compound plates, charcoal cast-iron is employed. The rough bars have a half fibrous texture and are of high resistance; they are selected according to the fracture and then re-rolled once or twice. After forging, the plates are molded to the form of the vessel by a 4,000 ton hydraulic press, and are then finished by planing and counter sinking.

The difficulty of fabricating hard steel plates without cracking has led to softer metals, but diminished resistance. The compound plate, with soft-iron backing and hardened face to shatter the projectiles, is a compromise between the two kinds of plates. Steel plates will probably be more and more used as experience is gained in treating the metal.

47-Millimeters (1.85-inch) Rapid-firing Gun.

This gun is the system known as "Daudetan et Darmancier," from the name of the inventors. The gun has a caliber of 47 millimeters (1.85-inch), is 45 calibers (83.27 inches) long, carrying a projectile weighing 1.49 kilograms (3.31 pounds), with a velocity of 620 meters (2,034 feet) per second. All the projectiles are of the same weight. Three kinds are used, as follows: Steel shell, 3.5 calibers long; shell, large cavity 4.5 calibers long containing 0.35 kilograms (0.77 pounds) charge, and shrapnel, with thirty-five balls, weight 18 grammes.

The breech fermeture is an interrupted screw and is smaller and lighter than the wedge generally employed.

A de Bange gas check can be employed if desired. The cartridge case acts as obturator, however.

The breech mechanism is borne by a console fastened to the rear face of the breech so that the motion of the block in opening and closing is simply a rectilinear motion.

There are two extractors which eject the shell in opening the block. The hammer can not strike the primer until the breech is fully closed. Two sights are used: one, to 1,200 meters, is the ordinary rifle sight placed in the breech hoop on the line of metal; the other, for long distances, is composed of a stem with a slide for a drift or wind on the right side of the breech hoop.

The gun rests in trunnion beds placed vertically in an elastic stand bolted to the deck or platform, and can fire in all directions. A steel shield protects the gunner against rifle fire.

To give rapid changes in elevation a toothed sector is fastened to the breech hoop on the right, and the piece is actuated by a spur wheel with a brake.

There is a loading box for ten cartridges placed on a table attached to the carriage, which enables the gunner to operate and load the piece himself. A series of plate springs (zigzag) elevate the cartridges as wanted, so that one is always ready for loading and is at the height of the trunnions.

80-MILLIMETER (3.15-INCH) MOUNTAIN GUN.

This gun is made in two sections, placed end to end for firing and held by interrupted screw threads. A metallic packing ring secures the joint and acts as an obturator. Two safety keys retain the sections in position relatively to each other. The de Bange fermeture is used.

Weight of gun	124 kilograms, or 273.3 pounds.
Weight of projectile	5.6 kilograms, or 12.35 pounds.
Initial velocity	305 meters, or 1,000 feet.
Muzzle energy	27.36 m. t., or 88.3 f. t.

The projectiles are (1) common cast-iron shell; (2) shell with large capacity, 4.5 calibers in length, containing 1.1 kilogram (2.42 pounds) of explosive; (3) steel shrapnel; (4) a canister.

The carriage is divided into four parts—the body, the trunnion support, with axle case and axle, the hydraulic brake, and the two wheels.

The body is a box trail of sheet metal, which carries the elevating gear. The trunnion support carries the trunnions, as its upper end oscillates upon the axle, which is strengthened by the axle case. The hydraulic brake permits the oscillation of the support, which brings it back to its original position after each shot. A movable key joins the body and axle case. The hydraulic brake is attached at one end to the body and at the other to the support. This arrangement permits of rapid mounting and dismounting of the system.

Three mules suffice for the transport of this gun and carriage.

80-MILLIMETER (3.15-INCH) FIELD GUN.

This gun is mounted on the regulation French field carriage. It fires the same projectiles as the mountain gun of same caliber, but with a velocity of 450 meters, or 1,608 feet.

The total weight of the gun is 425 kilograms, or 9,371 pounds.

The total weight of carriage and limber loaded is 1,560 kilograms, or 3,440 pounds.

SIEGE AND GARRISON ARTILLERY.

The discovery of new and more powerful explosives within the last few years has given a great impetus to the study of siege and garrison artillery by military engineers. It is not only that the power and precision of the pieces must be increased, but that at the same time the greatest possible mobility must be secured and a rapid method of bringing them in battery after firing.

Saint Chamond exhibited three types from among a number designed by them to represent the requirements of modern days, viz:

(*a*) A disappearing carriage on a rolling platform.

(*b*) Light 155-millimeter (6.1-inch) rifled mortar.

(*c*) A hydraulic brake for a 15-centimeter (5.9-inch) gun.

(A) DISAPPEARING CARRIAGE ON ROLLING PLATFORM.

The general plan of this carriage can be used for calibers up to 155 millimeters (6.1 inches).

The one on exhibition mounts the regulation 120-millimeter (4.72-inch) gun, and is said to have stood already two hundred rounds at all angles and in all directions. It can be used also for the 155-millimeter (6.1-inch) gun (short). The first fires a projectile of 18 kilograms (39.68 pounds) with a velocity of 480 meters (1,575 feet), and the second a projectile of 40 kilograms (88.2 pounds) with 291 meters (954.74 feet) velocity.

The carriage may be briefly outlined as follows:

The gun is supported on the upper end of a supporting lever which oscillates through one-third of its height about a solid axis on the chassis. The lower end of the lever is attached to the hydraulic brake. The body of the carriage is on the built-up or box system made of plates of metal to the interior of which is bolted the hydraulic brake. It is centered with reference to a circular rail bolted to the platform by a vertical pivot, and is furnished in front with two friction rollers which rest upon the circular track.

Elevation.—This is given by two lateral, inclined, and parallel screws transmitting simultaneously, through a jointed parallelogram, the ascending or descending motion.

Traversing.—This is obtained by rotating the chassis by hand upon the platform rail which is divided into degrees and half degrees.

The brake (patented by the company) is designed to utilize a part of the energy of recoil to bring the gun and carriage in battery. For this purpose it is made with two cylinders superposed, of which the pipe of communication can be opened or closed by two valves, called the one, check-valve, and the other, in battery, to indicate their functions. The piston of the upper cylinder is fastened to the end of the supporting lever by two lateral connecting rods; the piston of the lower cylinder is mounted on or loaded with Belleville springs.

Action of brake.—At the instant of firing the upper piston drives the liquid into the lower cylinder by raising the check valve, and compresses the Belleville springs with the remaining energy of recoil not absorbed by the motion of the liquid in the brake. At the end of the recoil the valve falls upon its seat and prevents the return of the liquid; the Belleville springs are now compressed and held and the gun has disappeared below the parapet or top of the turret.

The gun is loaded and pointed in this position and when ready to fire the in-battery valve is opened, permitting communication between the two cylinders; the springs expand and return the gun to the firing position.

The shifting of the carriage can be done by four men on the ordinary tracks; no turn-table is necessary for changing direction, as there is an arrangement for throwing the weight upon either group of axles which support the platform. These axles, placed in sets of two at right angles to each other, allow the immediate passage of the apparatus over two tracks intersecting at right angles.

The height of the gun on this carriage is: In battery, 2.75 meters (9 feet); in loading or eclipsed position 1 meter (3.28 feet).

The limiting angles of fire are as follows:

For the 120-millimeter (4.72-inch) gun—

Elevation	+30°
Depression	− 5°
Horizontally	360°

For the 155-millimeter (6.1-inch) gun, short—

Elevation	+45°
Depression	−5°
Horizontally	360°

(B) LIGHT 155-MILLIMETER (6.1-INCH) RIFLED MORTAR.

This mortar has 5 calibers (30.5 inches) length of bore and is composed of a steel tube hooped the whole length and furnished with the de Bange fermeture. The projectile, 5 calibers long (30.5 inches), is thrown with a velocity of 200 meters (656.17 feet). The shell carries 15 kilograms (33.07 pounds) of explosive.

In addition to the above the piece employs the following projectiles: The perforating shell, 2.8 calibers (17.08 inches) in length; the shrapnel, holding 620 balls of hardened lead; and the canister.

The carriage is composed of two flasks of sheet steel solidly transomed and carrying trunnion plates that receive the trunnions of the mortar. The mechanism moving the toothed arc for pointing is fastened to the right flask.

Two concentric curved flanges bind the carriage to the platform, for the movement of rotation serving to give the horizontal direction.

The limiting angles in elevation are from + 50 to + 60° and in traversing from 30° to the left to 30° to the right of the directrix of the platform.

As to the platform, it consists simply of a caisson lined with oak and carrying in rear a projecting traverse for increasing the adherence of the platform to the ground at the moment of firing. Some stirrups riveted to the front of the box trail and some flanges placed in the rear, serve to fix the false trail of the limber and to fasten the axle carrying the iron wheels. The whole forms a carriage of 2,000 kilograms (4,409.2 pounds) in weight.

(C) HYDRAULIC BRAKE FOR SIEGE AND GARRISON CARRIAGES.

In order to reduce the recoil of siege and garrison guns fired from wheels, a hydraulic brake has been constructed that limits the recoil to 1 meter (3.28 feet) as a maximum.

The employment of this system of brake increases sensibly the rapidity of fire and reduces perceptibly the length of the platform required.

The brake exhibited is that of the Royal Netherlands Artillery for the 15-centimeter (5.90-inch) gun. It comprises:

(1) A vertical pivot solidly anchored under the platform and projecting above the wood.

(2) A brake cylinder attached to this pivot and bearing on its interior surface grooves with a progressive twist.

(3) A piston pierced with conical orifices attached to the carriage near the trail.

The brake is so designed that the recoil will be progressively absorbed.

SEACOAST ARTILLERY.

In all the material for the armament of seacoast defenses and for naval vessels this company has established two types for each caliber from 15 centimeters (5.90 inches) to 42 centimeters (16.53 inches), one type heavy, the other type light.

The heavy type corresponds to a gun at least 36 calibers long, while the light type does not exceed 30 calibers in length.

The characteristic points of construction applied throughout this material are as follows:

For guns—

(1) The selection of a steel for the tube that will best resist the erosions of the gases in the bore.

(2) The employment of longitudinal frettage to avoid déculassement.

(3) The application of a safety device to the breech mechanism, which prevents the insertion of the primer until the breech is completely closed.

For carriages—

(1) The suppression of the rolling friction wheels.

(2) The horizontality of the upper faces of the chassis.

(3) The employment of hydraulic brakes with Belleville springs, a system patented by the company.

(4) The diminution of the total volume of the carriages.

(5) The simplicity of construction and ease of repair.

Following these general principles, the carriages constructed for the defénse of coasts or the armament of naval vessels are either center-pivot or front-pivot carriages; the only difference, depending upon their application, being the level at which the trunnions are held. This level is very low in naval carriages, and reaches a height of 2.5 meters (8.2 feet) in coast carriages.

The company also constructs a special disappearing carriage upon a fixed platform for coast defense.

The types were represented in the Exhibition by the following models and specimens, viz:

(1) A model, one-tenth size, of the light 275-millimeter (10.82 inches) seacoast gun carriage.

(2) A model, one-tenth size, of the light 200-millimeter (7.87 inches) seacoast gun with disappearing carriage.

(3) A 155-millimeter (6.1 inches) gun with front-pivot carriage for naval use.

(1) Light 275-Millimeter (10.82 inches) Seacoast Gun with Center-pivot Carriage.

This gun is being installed on the firing ground of this company, and is exhibited only as a model, one-tenth size, giving a general idea of gun and carriage.

DESCRIPTION.

(1) *Gun.*—The tube runs the whole length of the bore and at the rear end has the screw thread to receive the breech screw.

The tube is first hooped from one end to the other, then a second row of hoops for three-fourths of its length, over which are placed a series of longitudinal slabs or tension bars resembling somewhat the staves of a barrel; these bars are assembled on the gun with longitudinal shrinkage. A third row of hoops, including the trunnion hoop, is assembled over the whole system and prolonged until the hoops join those of the second row.

The forged longitudinal tension bars which form a kind of jacket are assembled with a longitudinal shrinkage such as to give a pressure not exceeding 20 kilograms (44.09 pounds) per square millimeter.

The fermeture is the de Bange system with the addition of a safety device to prevent the insertion of the primer until after the breech is closed and locked.

Length of piece, 30 calibers.
Diameter of bore, 275 millimeters (10.82 inches).
Weight of gun, 22 tons (21.65 t.).
Weight of projectile, 235 kilograms (518 pounds).
Initial velocity, 580 meters (1,902.91 f. s.).
Energy at muzzle, 4,030 t. m. (13,010 f. t.).

(2) *Carriage.*—This is a center-pivot carriage with a maneuvering platform in rear; it is to be made of steel castings and will have the same method of construction as the carriage for the 155-millimeter gun described below, with the addition of a support 0.9 meter (2.95 feet) high projecting from the platform to obtain a height of genouillère equal to 2.5 meters (8.2 feet).

The maneuvering platform carries the loading crane which is simply a rotating lever worked by hand.

(2) Light 200 Millimeters (7.87 inches) Seacoast Gun, on Disappearing Carriage.

This piece was exhibited by model also (one-tenth size), and is of the same construction as the 275-millimeter gun.

Length of bore is 30 calibers.
Total weight of gun, 8,400 kilograms (18,518.8 pounds).
Weight of projectile, 90 kilograms (198.4 pounds).
Initial velocity, 580 meters (1,902.9 f. s.).
Energy at muzzle, 1,540 t. m. (4,971 f. t.).

The carriage is a front pivot disappearing construction based on the same principles as the disappearing carriage, on a rotating platform heretofore described. Its principal parts are:

(1) A supporting lever, oscillating, and producing an eclipse of 1.4 meter (4.59 feet), and attached to the brake at about one-third of its height.

(2) A chassis, in which is placed and attached the brake apparatus, carrying in front a horizontal circular track and in rear two supporting friction rollers.

(3) A circular pivot-bolster, with its crown of friction rollers and its pivot.

Limiting angles of fire—

Elevation	+25°
Depression	—7°
Horizontally	150°

The traversing is obtained by the action of a pinion upon a toothed arc bolted to the bolster.

(3) HEAVY 155-MILLIMETER (6.1 INCHES) GUN, WITH FRONT PIVOT CARRIAGE, FOR NAVAL USE.

This gun is 36 calibers long and is built on the same principle as the 275 and 200 millimeter guns. The tube, however, has only one row of hoops assembled before applying the longitudinal shrinkage bars, which are then covered by a row of hoops, including the trunnion hoop.

The de Bange breech mechanism is used with a safety-bolt and detonating apparatus. Total weight of gun, 4,950 kilograms (10,912.9 pounds).

Projectiles. There are two types of these projectiles, one weighing 55 kilograms (121.25 pounds), having an initial velocity of 600 meters (1,968.5 feet) per second; the other weighing 40 kilograms (88.18 pounds), and having an initial velocity of 700 meters (2,296.6 feet) per second.

First type—

Armor-piercing shell, length 3.5 calibers; weight	55 kilograms (121.25 pounds)
Shell, long cavity, length 5 calibers; weight	55 kilograms (121.25 pounds)
Interior charge of explosives	10 kilograms (22.04 pounds)
Canister	55 kilograms (121.25 pounds)

Second type—

Armor-piercing shell, length 2.8 calibers; weight	40 kilograms (88.18 pounds)
Shrapnel containing 620 balls; weight	40 kilograms (88.18 pounds)

Carriage.—This is front-pivot, the component parts being made of steel castings.

The body is furnished with trunnion beds and plates which support the gun. The body slides directly upon the upper edges of the chassis rails without the interposition of friction rollers. These rails are horizontal to reduce to a minimum the reaction of the piece upon the deck of the vessel.

The chassis is made of two vertical, parallel flasks solidly united by trunnions; cavities are formed to permit the introduction of the springs and the large hydraulic brake cylinders; horizontal ribs on the sides serve for seats, to which are bolted the small cylinders whose pistons are fastened to the body of the carriage. The front transom has on its lower side a circular track resting upon the crown of friction rollers on the bolster. To the rear transom two friction rollers are fastened which rest upon a circular rail, concentric with the center of motion on the bolster.

The bolster and rails are bolted to the deck, the former being the fixed point which holds the carriage. The pointing is done by means of toothed-gear, as in the 275-millimeter carriage.

Limiting angles of fire—	
Elevation	+ 30°
Depression	— 10°
Horizontally	120°

The hydraulic brake consists of two sets of twin-cylinder brakes of the ordinary type made by the company, *i. e.*, comprising each a large and a small cylinder connected by a tube of communication. The pistons of the small cylinders are fastened to the body of the carriage, and those of the large cylinders transmit the remaining energy to the nests of Belleville springs placed between the rails of the chassis. In mounting the carriage the small pistons must be subjected to an initial pressure sufficient to sustain the body of the carriage in a fixed position, no matter what may be the inclination of the vessel.

ARMORED TURRETS.

St. Chamond constructs armored turrets of all sizes, from those fitted for the largest caliber seacoast guns to those for mitrailleuses. Five models were exhibited which represent twelve principal types made by the company.

(1) TURRET WITH HYDRAULIC PIVOT AND FRICTION ROLLERS AT THE UPPER PART, FOR THE DEFENSE OF FORTRESSES.

This turret is 6 meters (about 20 feet) interior diameter, and is armed with two 15-centimeter (5.90-inch) guns, and is armored with wrought-iron plates 24 centimeters (9.45 inches) thick.

Like all turrets, the metallic part comprises a fixed part and a movable part. The first is composed of chilled cast-iron voussoirs of about 30 centimeters (11.8 inches) in thickness, forming an exterior ring 6.1 meters (20.01 feet) in diameter. This is the secondary armor or avant-cuirasse.

The second is a metallic framework supporting the guns and carriages and the armor plates which protect them, the whole resting on twelve vertical friction rollers and guided by ten horizontal centering friction rollers.

The lower crown is riveted to three large vertical beams which serve as chassis for the carriages. The latter, movable in guides and balanced, can easily be given the necessary inclinations for elevating and depressing in pointing. The horizontal pointing is accomplished by the traversing or rotation of the turret itself.

In order to facilitate this rotation, the entire movable part bears upon the head of a hydraulic piston, and can be raised to diminish very perceptibly the pressure on the bearing rollers.

A windlass on the lower floor of the masonry substructure gives the rotation. Smaller capstans conveniently placed enable the gunners to raise the ammunition necessary for the service of the piece from the chambers below.

There are two points characteristic of this turret-construction:

(1) The application of the company's patent system of brakes to the carriages, being the combination of an hydraulic brake and a metallic Belleville spring brake, whereby the first absorbs almost all the energy of recoil and the Belleville springs store up the remaining energy to be used at will to bring the piece back in battery.

(2) The employment, for pointing, of a large brass circle, 4.5 meters (14.76 feet) in diameter, fastened to the wall of the upper floor and divided into degrees and minutes; sliders placed in advance at the proper divisions come in contact at each rotation of the turret with points attached to the movable part, and fire the pieces by electricity the moment that the gun arrives in the plane of fire previously chosen.

This is the turret as modified after the trials at Cotroceni near Bucharest.

(2) TURRET WITH OPTIONAL HYDRAULIC PIVOT AND FRICTION ROLLERS ON THE LOWER PART.

This also has a diameter of 6 meters (about 20 feet) and is armed with two 15-centimeter (5.90-inch) guns. The secondary armor, or avant cuirasse, and the calotte, or dome, does not differ perceptibly from the preceding turret.

In this turret, however, the movable armor plating rests on a cylindrical well of great height braced by a strong framework of sheet metal and angle iron at the level of the loading floor. The whole, through the medium of a circular caisson, rests upon a crown of conical friction rollers. In the center is a press cylinder and its hydraulic piston, which can act as an elevator or simply as a vertical centering axis; all is so arranged that the rotation will be easy even when all the weight is thrown upon the friction rollers.

The method of centering is one of the characteristics of this construction. It is secured at a very high level, a few centimeters below the movable armor plates, by horizontal friction rollers running upon a track fastened to the interior wall.

In this type the substructure can have one or two floors. In the first case the press cylinder is sunk in the ground and the maneuvering windlass is in the well of the stairway. In the second case (as in model shown) the lower floor is disposed as in the preceding turret.

In the spherical roof armor is an opening closed by a sort of clack valve. If required, this opening can be used for direct pointing, and

to facilitate this operation the gunner has at hand a supplementary windlass with a brake for slow movement.

(3) Turret without pivot for two 15-centimeter (5.9-inch) guns.

Hydraulic movement is entirely avoided in this turret; it is without pivot; it rotates on a crown of independent friction rollers resting on a circular track set in the masonry about half the height of the movable body of the turret. The hydraulic cylinders for pointing in elevation being suppressed, the gun and carriages are balanced as in the other turrets, and are trained by hand with the toothed-gear arrangements.

The suppression of the pivot gives more space in the gun chamber and renders communication with the different parts more easy and rapid. In other respects it is similar to the preceding turrets.

The above turrets have been described in the technical reviews, but these are not available to the general public, so a short sketch was inserted here.

The three turrets described below represent the more recent studies of Commandant Mougin.

(4) Oscillating disappearing turret for two 15-centimeter (5.9-inch) guns.

Rotating turrets present serious advantages so far as accuracy of fire is concerned and the ease of its execution, but have the disadvantage of leaving the embrasures and muzzles of the pieces exposed to ricochet shots, which can produce considerable and even grave damage; hence disappearance or eclipse is naturally the solution sought to parry these accidents. Disappearance may be effected in various ways, but the usual method, by lowering the turret directed by the vertical axis, complicates the construction and renders it burdensome. The proposed solution is a type called "oscillating," and consists in a movement from front to rear, and *vice versa* around a horizontal axis passing through the center of the sphere of which the armored dome is a segment.

The movement is made by hand when the guns are loaded and pointed; after firing, the return to the loading or screened position is obtained in 5 seconds.

The armor plating preserves in its entirety the form of the spherical dome adopted for the preceding turrets and found by experience to be valuable; at the same time, thanks to this form, at the moment of coming in battery no change in the appearance of the turret indicates to the enemy that it is prepared to fire.

For maneuvering or putting in battery and returning to the eclipsed position, the movement is obtained by training upon a drum, fixed to the movable part, two cables wound in contrary directions; the ends being attached, one to the drum and the other to the fixed

part of the turret. The system, therefore, requires neither a steam engine nor an hydraulic apparatus of any kind.

The guns do not project outside of the armor plating, and the obturation of the embrasures is complete. No shell fragments can penetrate to the interior and the guns are entirely sheltered.

The guns have no carriages, which simplifies the construction greatly. Their trunnions, moving between the two elements of a curved guide, describe, at the moment of pointing, an arc of a circle whose center is near the muzzle of the piece. The mass of the gun being *in equilibrio*, this movement, with limits of $-1°$ and $+25°$, is obtained easily, and the exact inclination is given by noting the definite position of "in battery" given at the moment of firing by the movable part of the turret. This position remains rigorously the same from salvo to salvo owing to the arrangement of the abutments.

The traversing, elevation, rotation of the turret, supplying with ammunition, mode of action, etc., are about the same as in the preceding turrets, but the personnel can be reduced to a minimum of five men and one noncommissioned officer. The form permits an excellent ventilation.

(5) SMALL DISAPPEARING TURRET FOR TWO LIGHT 47-MILLIMETER (1.85-INCH) RAPID-FIRING GUNS.

The employment of mitrailleuses and rapid-firing guns against armed forces has naturally led to seeking for some means for protecting them, and giving them sufficient resistance to withstand attack from curved fire of large shells and from the direct fire of the enemy's field artillery and rapid-firing guns. At the same time it must be as simple as possible in construction, and easily manipulated, and its cost price must be in proportion to the value of the guns it protects.

This turret is a sort of sentry box, in strong plate metal, about 2 meters (6.56 feet) in diameter, containing the guns and surmounted by an armor-plate top, capable of resisting shells of large caliber coming from above and the direct fire of field guns.

The vertical movement of this sentry box proceeds from a balance beam, with a horizontal axis, fastened to its lower part and counterpoised by a weight, which equilibrates the turret and its armament. A single man inside, by means of toothed wheels, can raise or lower it, put it in battery, with a projection of about 0.30 meter (0.98 foot), or about 1 foot, sufficient for firing these guns, or rotate it to the eclipsed position, where it is screened by the avant cuirasse or secondary armor in front.

The duration of the maneuver is about five seconds. A movement of rotation upon friction rollers allows the pointing in direction and at the same time it permits, after a few centimeters displacement

out of eclipse, the use of the apparatus for observing the approaches to the work. A special machine has been created, however, for this special application.

(6) DISAPPEARING ARMORED OBSERVATORY OR CONNING TOWER.

This apparatus is very close in its resemblance to the above turret, only its proportions are a great deal less, and its diameter is only about 1 meter (3.28 feet); but the armor plate which protects it is 0.30 meter (0.98 foot) in thickness, to enable it to resist, in case of necessity, 15-centimeter (5.9-inch) projectiles.

The interior arrangements are such that it can be rotated or made to disappear by a single man inside at the same time that he is making observations.

(7) PLAN OF FORT BY COMMANDANT MOUGIN.

The most important details of this project have been described by Gen. Brialmont in his "Les nouveaux explosifs et la fortification." This is a new type of fortification.

This plan supposes an immense monolith of béton, in which all chambers and passages and turret emplacements have been reserved in building.

The plan exhibited comprises a fort with one disappearing turret for two long 15-centimeter (5.9-inch) guns; two for indirect fire, armed with the same guns; four disappearing turrets for rapid-firing guns; four armored observatories or conning towers.

In the center of the fort is a large hall covered by a minimum thickness of 3 meters (9.84 feet) of béton where all the subterranean passages, magazines, machine rooms, etc., end, so that the commander can have all the personnel in hand as if on the deck of a vessel.

A garrison of fifty or sixty men is all that is required to manipulate all the turrets, guns, and machines.

This garrison reaches the port by a subterranean gallery about 200 meters (218.7 yards) long and gains access to the surface by a shaft or well about 20 meters (65.6 feet) deep. For the defense of the mouth of this well a spiral stairway is built in a cylinder made of armor plate, which rests upon a piston whose vertical play is 2 meters (6.56 feet). In changing the reliefs, the piston is raised, carrying up the cylinder, the men enter or go out as the case may be, and then the cylinder is lowered out of sight and the hole is closed by the armor-plate top which protects the stairway from the heaviest projectiles.

This type of fort established, armed, and defended as well against attacks by armed forces as their artillery, can furnish an example of exceptional resistance. The great difficulty will be in the hygienic point of view; great precautions will have to be taken to

secure proper supplies, ventilation, drainage, lighting, etc. These done properly and satisfactorily, the new fort of Commandant Mougin will stand indisputably as an obstructive defense of the first order.

THE DAUDETEAU 8-MILLIMETER (0.315-INCH) MAGAZINE RIFLE.

This small arm is made by St. Chamond and is a rapid-firing rifle of small caliber, high velocity and flat trajectory. Two specimens were exhibited exactly the same except as to the position of the magazine. In one the magazine is in rear of the chamber, in the stock; in the other it is under the barrel.

The projectile is of lead, covered with an envelope of German silver. It weighs 15 grams and the initial velocity with common powder is given at 550 meters (1,804.48 feet) and with special powders it is said to exceed 600 meters (1,968.52 feet) per second. The minimum rapidity of fire is said to be two shots per second. (?)

The special feature of this arm is that all the motions of loading are performed by a simple rectilinear motion of the slide bolt. The breech mechanism is simple and solid and the arm is arranged to fire at will, either shot by shot or with simple repetition, or with repetition and rapid fire. The firing pin can not move forward nor the trigger act until the breech is closed.

The repair is easy and the dismounting requires the removal of no screw, since all the pieces are assembled either by means of dovetails or smooth tenons.

The weight of the gun, with sword bayonet, and with magazine filled, is 4.5 kilograms (9.92 pounds).

CHAPTER VII.

SOCIÉTÉ ANONYME DES FORGES ET CHANTIERS DE LA MEDITERANÉE.

CANET SYSTEMS.

This company is the most important among the works engaged on French naval constructions. It has establishments at Marseilles, at La Seyne, near Toulon, and at Le Havre. The latter place now has all the factories for war material.

Mr. Canet, the former collaborator of Vavasseur, organized the special service for artillery, and is now the director of that department.

The plant now is sufficient to finish guns of all calibers, from a mountain gun to a 100-ton gun.

There is a firing-ground at Havre where all pieces can be proved after fabrication.

The whole exhibit of this company—guns, carriages, turrets, torpedo tubes, etc.—belong to the Canet system.

The guns differ from the regulation models of all countries in plan and the details of construction. Mr. Canet, like other French engineers, lays great stress upon securing great longitudinal resistance as well as transversal, in order to stand the abnormal stresses sometimes unaccountably developed in the bore.

The elements of the guns are of the usual form for easy application of forging, tempering, and annealing.

A long tube of great thickness extends through the whole length of the piece. Two long cylinders or jackets, with coupling shoulders, joined to each other by the trunnion hoop, and assembled on the tube with "energetic shrinkage," the one from the rear and the other from the front, clasp and bind together the front and rear portions of the tube in such a manner as to produce of these two important elements a solid whole. This body is then reinforced by one or more rows of long hoops.

All the surfaces are cylindrical, which is a great advantage for easy fabrication and for assemblage. The long jackets and hoops can not, on account of their length, be so rapidly and accurately measured on their interior surfaces as shorter hoops, but still it can be done with the proper expenditure of time and care. Nor can the finish-boring of a long surface be so accurately done as in a shorter

hoop. There will be more variation in the diameters of the various sections and in the eccentricity. Still the advantage of long hoops and jackets in giving stiffness to the structure and in diminishing the number of joints will, if proper care be taken in finishing, measuring, and assembling, probably more than counterbalance the loss of accuracy and errors in measuring, due to the employment of long pieces whose interior dimensions are inconvenient to verify as compared with shorter ones.

The hooping, or rather jacketing, extends to the muzzle, to give greater strength and resistance in view of the use of slow-burning and smokeless powders, which keep up a considerable pressure until the projectile leaves the bore.

This mode of construction is entirely different from that of Col. de Bange, who extols the biconical hooping, where each tooth of the very flat serration corresponds to one hoop. There have been and will be many discussions as to the relative value of these two methods of hooping, but experience alone will be able to settle it. There can be no doubt among those who are familiar with the manufacture of such pieces that the Canet surfaces are easier to verify in their measurements on account of their cylindricity, which will add much to the accuracy of fabrication, a point of great value in constructing built-up guns, where a change of a few thousandths of an inch may imperil the life of the piece.

Mr. Canet employs the large chamber, so as to obtain higher velocities. He claims to have obtained velocities exceeding 700 meters (2,297 feet). In this practice he is opposed by the other French engineers.

The Canet fermeture is an interrupted screw with a plastic obturator. When the breech is closed unscrewing is impossible, and when the screw is withdrawn it is borne by a console or swinging bracket pivoting around a hinge fastened to the breech.

The breech mechanisms are all furnished with a safety device to avoid premature firing.

Mr. Canet employs a new method of opening the breech by the single movement of a horizontal lever from right to left. In heavy guns the manipulation of the breech is done by a single crank, turned always in the same direction, which renders the operating more easy and expeditious than in the case where two crank levers are used, one to rotate the block and the other to withdraw it.

The improvements embodied in the breech screw for the different guns will be given below.

(1) Fermeture for rapid-firing guns.

(Plate XXIX.)

In this fermeture the three motions for opening the breech block, viz: Rotation of block, motion of translation or withdrawal, and

revolution clear of the mouth of the chamber, are all performed by a single lever carried from right to left. The screw is cylindrical, or a truncated cone. It carries on its exterior face and in the prolongation of its axis a trunnion, *a*, furnished with a bushing, *b*, in which is embedded a vertical pivot, *c*. A handle, *d*, is rigidly fastened to this pivot, which can be moved from right to left, giving a motion of rotation.

The breech screw has on its rear face a toothed segment, *e*, engaging a beveled pinion, *f*, attached to the vertical pivot.

The firing mechanism.—The piece is fired by means of a firing-pin, *l*, with a spiral spring seated in the breech screw in the prolongation of the axis of the bore. The firing-pin carries two rings between which is inserted the end of a small lever, *m*, whose other extremity passes along a groove cut in the body of the gun and whose form is such that the lever, and therefore the firing-pin, can only act when the block is completely closed. Hence this arrangement plays the part of a safety device. When the firing lanyard attached to the sear *n* is pulled, the sear acts upon the detent *p*, which oscillates and frees the firing-pin. The latter, actuated by the spiral spring, is thrown forward and strikes the primer, igniting the charge.

Extraction.—The extraction is automatic. It is effected by claws lodged in the breech screw, which seize the head of the cartridge case and withdraw it as the block moves to the rear.

Action of breech mechanism.—The lever being in its normal position it is drawn forcibly to the rear. The vertical pivot in turning rotates the breech screw one-eighth of a turn by means of the toothed gear and disengages it from its female-screw box. The movement of this lever continuing, a friction roller, *g*, placed at the end of a small arm forged solid with the lever, enters a lateral groove, *h*, in the console until it brings up at the end, where it acts as a fulcrum to displace the vertical axis of its sliding block, *k*, along the slide of the console, dragging back the block until the slide block *k* abuts against the end of the slot. Still continuing the motion of the lever *d* from right to left, the console, carrying the block, rotates around its hinged axis and uncovers the mouth of the powder chamber.

To load the gun place the cartridge in the chamber and carry back, from left to right, the lever to its normal position.

The action is simple, easy, and rapid ; the obturation perfect, and the extraction good. The safety arrangement prevents premature firing.

A spring catch, *x*, serves at one moment to connect the console and gun rigidly, and at another the console and breech screw.

In his later rapid-firing guns Mr. Canet has adopted electric primers in order to avoid the danger of premature explosion of the fulminating primers by accidental shocks.

The wire is cut off flush with the primer in the base of the projectile and rests continually in contact with a needle arranged in the axis of the screw and pressed against the primer by a spiral spring. Upon this needle, insulated by ebonite rings, is mounted an insulated metallic conductor placed perpendicularly to the axis. A flat spring serves to establish communication between the conductor and the post or button upon the breech of the piece. It is only when the breech is completely closed that the circuit is completed and that firing becomes possible.

A second post serves to fasten the return wire to the body of the gun. The two wires are joined in the same cable and are led to a circuit-closer placed upon one of the flasks of the chassis.

(2) FERMETURE OF MOUNTAIN AND FIELD GUNS.

The three Canet guns, field gun, short and long, and the mountain gun, have the interrupted screw fermeture. The obturation is obtained by means of a plastic disk held in two metallic cups reënforced by rings of a special design. Each breech mechanism has a special arrangement.

Long field gun.—This has the Hartmann safety device used by the French artillery on some of their guns. This apparatus has a projecting arm which covers the vent and prevents charging the primer or firing until the breech is closed. The parts are arranged as simply as possible, and all cavities for the lodgment of dust are avoided. This also facilitates repairing and cleaning. The piece is fired with a friction primer.

Short field gun.—This piece is fired with an obturating percussion primer. A bolt carrying a hammer slides upon the rear face of the screw. When the lever is raised an arm engages in a notch in this bolt and forces it down. During this movement a bearing face encased in a cavity of the breech screw acts upon the tail of the hammer and cocks it. When the breech screw is turned a claw-extractor removes the primer from its seat.

Load the piece and close the breech again. A pawl prevents the rising of the bolt and therefore the discharge of the piece before the breech is fully closed. After closing pull the firing lanyard, which acts upon a hook forming part of a small pinion mounted on the lever axis. The pinion engages the ratchet on the bolt, raises it, and permits the hammer to strike the primer.

Mountain gun.—This is fired with a friction primer. The gun has the Canet safety device. When the lever is raised the point forces down a sliding bolt that carries a safety arm which projects and covers the vent. The bolt is raised again when the handle is lowered. The latter can not be lowered until the breech is closed. Hence the vent is covered and can not be charged until the mechanism is locked.

The system is easily dismounted and cleaned.

(3) Fermeture of heavy guns.

(Plate xxx.)

The breech screw has upon its rear face a toothed sector, *a*, engaging a rack, *b*, upon a movable nut, *c*, mounted upon a vertical screw, *d*, attached to the console.

By rotating the screw *d*, the movable nut *c* rises, and its rack acting on the toothed sector rotates the breech screw until the interrupted threads are disengaged. The nut, in mounting, until the upper end of its sleeve abuts against the upper support of the breech screw, carries with it the pinion *e* with helicoidal teeth, which latter interlock with the thread segments on the breech screw and withdraw it from its seat.

During the rotation of the screw the tail of the bolt carrying a friction roller mounts a small circular ramp fastened to the face of the breech. The bolt goes up and the tail of the hammer meets a bearing face, which forces the hammer to rise to the position of full cock. This cocking is therefore automatic.

When the screw is fully withdrawn, the pinion *e* abuts against the end of the threaded part and is stopped. A catch, *i*, which clamped the console to the gun, is freed, and the entire system rotates around the axis *g*, attached to the gun.

The console latch is very simple, and has no spring. The axis *g* at its lower end has a pinion, *f*, which engages an endless screw mounted on an arbor actuated by the crank *k*.

The manipulation of the breech is done by hand, by hydraulic apparatus, or by transmitted power, and is easy and rapid, due to the suppression of inclined toothed gear and the judicious arrangement of the several parts.

The great advantage of this system is that the breech mechanism can be operated in all positions of the gun by a single gunner with a single crank.

The breech mechanism has a triple safety apparatus that prevents firing the piece—

(1) So long as the breech screw is not completely engaged in its nut.

(2) So long as the bolt is not over the primer.

(3) So long as the firing lanyard is not pulled.

(4) Canet seacoast carriages with hydraulic brakes.

(Plates xxxi and xxxia.)

With the high powered gun now made the question of carriages is of special importance. The energy of recoil to be absorbed is so great that very resistant carriages are required. With diminished recoil is also imposed the task of supplying an apparatus, light,

easily handled, and of as small volume as possible, in order to increase the rapidity of fire, an essential condition of modern artillery.

The first carriages constructed by Mr. Canet resembled the Vavasseur carriage, but differed perceptibly in the details and general arrangements. The new carriages are changed in all their details from the primitive models.

There are now two kinds of carriages:

(1) Carriages made of cast iron—heavier but more economical.

(2) Carriages made of steel—lighter and more easily transported, but more expensive.

Each carriage has three principal parts: (1) The carriage proper, or top carriage; (2) the chassis, and (3) the bolster or saddle.

The top carriage supports the gun by means of its trunnions and rests upon the inclined slide rails of the chassis or on friction rollers mounted on the upper part of the chassis. It also carries the cylinders of the hydraulic brake and the elevating apparatus.

The chassis is a spherical dome whose base rests upon a crown of friction rollers; the two flasks, cast solid with the dome, support the rollers for the carriage, and are fastened to each other and to the spherical dome by strong transoms. In front and rear of the chassis are heurters and counter heurters to prevent upsetting.

The bolster, a single piece, furnishes a seat for the center pivot, about which the chassis is traversed, and forms the bed for the circular track upon which the friction rollers carrying the chassis travels.

The elevating apparatus is a toothed sector fixed to the gun. The hand wheel is mounted on the left brake-cylinder. This arrangment avoids long shafts which might be bent by firing or injured by a fragment of an exploding projectile.

The traversing is done by an endless chain wrapped around the dome or bolster and wound around a windlass on the chassis, worked by two cranks perpendicular to the flasks.

A tension screw enables the length of the chain to be diminished and compensates for the elongations taking place in service.

This mechanism is very rough, and suited to coast carriages whose repair is often difficult. The repairs are more easily made than when a toothed crown with a pinion is used; especially so when this toothed crown is cast solid with the bolster, which renders rapid repairs upon the spot impossible. This crown rack, subject to rusting and to being filled with mud and dirt by rain and the bursting of shells, is one cause of the great difficulty in traversing.

The crown of friction rollers, interposed between the bolster or saddle and the chassis, permits the handling of the heaviest carriages with very little effort, since it substitutes rolling for sliding friction. Besides, this crown distributes the shock of firing more uniformly over the surface of the bolster. The rollers keep their relative dis-

tances by means of circles carrying slots in which the axles of the rollers are placed. A flange, placed either upon the bolster or upon the rollers, prevents all displacement of the latter; consequently the chassis rests upon all the friction rollers.

Moveable covers allow the cleaning of the apparatus.

The friction rollers can be inspected one by one. For this purpose at one point of the bolster is a cut a little larger than the roller, in which is lodged a shoe whose upper surface is a continuation of the circular track. Remove this sabot and turn the carriage, and as each roller passes this cut it falls and may be taken out, inspected, or replaced.

Mr. Canet employs his own system of hydraulic brakes in which the size of the orifices is determined by a central counter piston. The improvements made enable him to vary the size of the orifices through which the liquid must pass, in any manner whatever, so as to follow, step by step, the variation of energy of the gun and carriage. In this way the maximum useful effect is obtained from the brake, and at the same time the shocks and sudden jerks, which are the causes of great strain on the carriage, are suppressed.

When the recoil is terminated, the carriage returns in battery under the action of gravity by rolling on the rollers of the flasks of the chassis. A special arrangement of the piston permits using the brake during the return in battery as well as during recoil. Hence the gun can be brought in battery with a velocity so slight as to avoid all shocks.

The running from battery is done mechanically or by means of an hydraulic apparatus seated in the carriage, which does not need the assistance of a tackle.

The loading is done by a ladle carried by an arm fastened to a horizontal arbor, perpendicular to the flasks, by means of a cam with a variable radius upon which is wound a chain acting upon a set of springs. In order to make the effort upon the operating crank sensibly constant in all positions of the loading lever, the apparatus is so arranged that the springs close on each other while the ladle is descending empty, and consequently the same springs, by distending, diminish the labor during the ascent of the projectile. These have been tested and adopted by France for the coast armament.

To recapitulate, then, Canet's carriage presents several advantages:

(1) Reduced dimensions, which permit the use of carriages at once resistant, light and not encumbering, whose essential parts can easily be protected.

(2) Single solid bolster upon which the whole system rests, assuring satisfactory action of the carriage, notwithstanding the displacements and settling of the soil which may be produced. With a bolster or saddle in two parts, difficulty of maneuver is likely to be experienced from the displacement of one of the circular parts with respect to the other.

(3) A chassis formed of two flasks carried by one spherical dome that distributes uniformly the pressures upon all the friction rollers.

(4) A crown of friction rollers diminishing the force required for rotation and distributing the pressure uniformly over the bolster.

(5) A lateral chain-traversing mechanism, very rough, easily reparable, which combined with the crown of friction rollers requires the minimum effort for working.

(6) Top carriage very low, with brake cylinders so disposed as to give the minimum couple tending to upset it.

(7) Brake with central piston limiting the recoil of the piece, arranged to oppose a constant resistance during recoil and during the automatic return of the carriage in battery.

(8) Loading the piece by means of a lever with accumulating springs, thus facilitating and accelerating the operation.

(9) The rolling apparatus perfectly protected by plates.

(5) Canet 320-millimeter (12.6-inch) gun, 40 calibers long, with armored turret.

The gun is constructed on the principles previously stated. The breech mechanism is operated mechanically by a single crank, turning constantly in the same direction, unlocking and withdrawing the screw and rotating it about the hinge axis.

	Kilograms.	Pounds.
Weight of gun	66,000	145,505
Weight of projectile	450	992.08
Weight of powder charge	280	617.3

The gun is mounted on a hydraulic carriage with movable chassis protected by an armored barbette and a carapace or rounded cover made of armor plates. The work of putting in battery, from battery, elevating, traversing, and transporting ammunition is executed by hydraulic apparatus under a pressure of 80 atmospheres (about 1,180 pounds per square inch).

The distinctive character of this turret is that the ammunition is carried directly from the shot lockers to the breech of the gun by a shot carrier mounted in a central tube moving with the rotating platform carrying the gun and carriage. This device allows the gun to be loaded in all positions without having to be brought back to a special position for loading. The gunner can thus follow the moveable target without annoying himself with the loading of the gun.

The gun and turret exhibited are intended for the armored-clad guardship *Matsushima* now building for the Japanese Government at the dockyards of La Seyne, near Toulon.

(6) Canet 270-millimeter (10.63-inch) gun, 36 calibers long, upon a barbette turret carriage.

Like the preceding gun, this is maneuvered mechanically. It is mounted on a common chassis carriage installed in a barbette turret protected by a turtle back.

The loading is done through a central tube as in the previous gun. The traversing is done by steam power, but the carriage is so arranged that it can be traversed by hand. The elevation is given by hand.

	Metric.	English.
Weight of gun	352,000 kilograms	778,234 pounds.
Weight of projectile	250 kilograms	551.15 pounds.
Weight of powder charge	142 kilograms	313.05 pounds.
Total weight of carriage	17,150 kilograms	37,808.7 pounds.
Initial velocity	670 meters	2,198.2 feet.
Thickness of wrought-iron plate perforated:		
At muzzle	0.720 meter	28.35 inches.
At 1,000 meters	0.630 meter	24.80 inches.
At 2,000 meters	0.560 meter	22.05 inches.
Maximum range	17,700 meters	11 miles.

(7) Canet 270-millimeter (10.63-inch) gun, 36 calibers long, on center-pivot carriage.

The gun is mounted on a carriage designed for an armored keep. It is protected by a shield of special steel. The system is worked by hand. The elevating gear is a new mechanism with an eccentric that diminishes the force required and at the same time increases the rapidity of handling.

Six guns of this type, and three of 30 calibers in length are being constructed for the armament of three vessels ordered by Greece from the company.

(8) Canet 270-millimeter (10.63-inch) gun, 30 calibers long, on center-pivot carriage.

[A cast-iron gun, hooped and tubed with steel.]

(Plate XXXII.)

This gun is of a special model made of cast-iron hooped and tubed with steel. It is more economical than an all-steel gun.

The steel tube extends the whole length of the bore. The body is reinforced with steel hoops. The steel tube increases the resistance and the life of the piece by preventing the erosions of the bore, while, at the same time, it permits the use of slow powders.

The mounting is a cast-iron center-pivot carriage of the same type as those delivered by Mr. Canet to the land and marine artillery for

270 and 320 millimeter guns, and which have been tested and adopted by France for the coast armament.

	Metric.	English.
Weight of projectile	216 kilograms	476.2 pounds.
Weight of powder charge	76 kilograms	167.55 pounds.
Initial velocity	570 meters	1,870 feet.

This gun was made for Japan and is intended for coast armament.

(9) Canet 150-millimeter (5.9-inch) guns, 36 calibers long, upon center-pivot and front-pivot carriages.

These two guns are constructed similarly to the 270-millimeter guns, but the breech mechanism is worked by hand. One is mounted on a center-pivot carriage, the other on a front-pivot carriage.

The latter is a new model. The pivot bolt has been omitted and the bolster is in a single piece, the better to distribute the pressure over the deck. The running from battery is done by hand with an hydraulic pump.

Fifteen guns of this type have been ordered for the armament for the three Greek cruisers constructed by the company.

	Metric.	English.
Weight of gun	6,280 kilograms	13,845 pounds.
Weight of projectile	42 kilograms	92.6 pounds.
Weight of powder charge	27 kilograms	59.5 pounds.
Total weight of carriage	3,150 kilograms	6,944.6 pounds.
Initial velocity	700 meters	2,297 feet.
Thickness of wrought-iron plate perforated:		
At the muzzle	0.350 meter	13.78 inches.
At 1,000 meters	0.270 meter	10.63 inches.
At 2,000 meters	0.210 meter	8.27 inches.
Maximum range	15,000 meters	9.32 miles.

(10) Canet 150-millimeter (5.9-inch) gun, 26 calibers long, upon disappearing siege and seacoast carriage.

This piece is of the same type as the preceding, but is claimed to be more powerful than the majority of guns employed in similar positions.

The gun is mounted on a disappearing carriage, whose brake is situated in a horizontal plane. The system consists of a counterpoise lever, sustaining the trunnions. This lever pivots around a cylinder carried by a rotating platform which rests on a bolster, through the interposition of a crown of friction rollers, and encases the bolster pivot or pintle. The movable platform carries a brake designed to limit the recoil. This brake is a press cylinder, in which

moves a perforated piston, the area of whose orifices varies according to a certain law. The piston, held by a movable sliding block between two guides of the platform, is attached to two connecting rods, the other ends of which are fastened to the arms of the counterpoise lever.

From the end of the brake cylinder starts a pipe, furnished with a valve. The pipe is divided into two branches that end in air accumulators, lodged in the tambours or cylinders, serving as trunnions for the counterpoise lever.

The air is compressed by means of a small auxiliary pump.

The gun is supported in front of the trunnions by two connecting rods carried by slide blocks. These blocks slide in guide grooves cut in the ends of the arms cast on the support of the counterpoise, and are supported themselves by articulated arms mounted on the support, and carry a toothed arc which engages with pinions. These pinions are actuated by an eccentric apparatus that makes the handling very easy. An index, moving over a graduated circle, indicates at each instant the position of the gun.

The traversing is done by hand with a lever inserted in a socket.

The rear crossbar carries spring buffers upon which the carriage rests in recoil.

In firing, the gun recoils parallel to itself, always bound to the counterpoise which pivots around its axis. During this movement the lower arm of the counterpoise lever acts through the connecting rods upon the piston rod of the brake. A volume of liquid corresponding to that of the piston rod escapes into the accumulators after raising the loaded valve.

At the end of the recoil the valve falls back upon its seat and the gun is motionless. The piece is loaded in this position. To run in battery, open the communication between the cylinder and the accumulators by means of a special pipe. This is done by turning a valve whose orifice ends below the loaded valve.

The liquid, acted on by the compressed air, will return to the cylinder and run the gun in battery with a velocity which is regulated by the degree of opening of the valve. The composite system pivots again around its axis and the piece returns to its firing position.

The angle of elevation can be verified and readjusted, if necessary, by the graduated circle. The carriage is protected by a steel-plate shield, with a hole cut for the passage of the gun.

The working of the gun is very simple: The piece being lowered, it is loaded, pointed, then the return valve is opened and the gun returns in battery; as soon as fired the piece lowers itself again.

The advantages claimed for this system are its simplicity and freedom from cumbersome details. The horizontal arrangement of the cylinders give a better distribution of the forces and a greater

magnitude of eclipse than can be obtained with carriages with oscillating cylinders.

The oscillating cylinders, not having as much depression, require higher parapets, which adds to the expense of the emplacement.

Again, in sunken batteries, not having to lodge oscillating cylinders, the wells for installing the carriage require less depth and less diameter.

	Metric.	English.
Weight of gun	2,750 kilograms	5,662.6 pounds.
Weight of projectile	35 kilograms	77.2 pounds.
Weight of powder charge	9 kilograms	19.8 pounds.
Total weight of carriage	6,500 kilograms	14,330 pounds.
Initial velocity	520 meters	1,706 feet.
Thickness of wrought-iron plate perforated:		
At the muzzle	0.230 meter	9.05 inches.
At 1,000 meters	0.180 meter	7.08 inches.
At 2,000 meters	0.140 meter	5.51 inches.
Maximum range	10,500 meters	6.52 miles.

(11) Canet 150-millimeter (5.9-inch) mortar and 150-millimeter (5.9-inch) howitzer on counterpoise carriages with circular brake.

(Plate XXXIII.)

The shell for Canet (5.9-inch) mortar weighs 32 kilograms (70.5 pounds) and has a velocity of 200 meters (656.2 feet). The howitzer fires the same projectile with a velocity of 300 meters (984.3 f. s.).

The interrupted screw fermeture of these two arms have the blanks, and consequently the threaded segments, helicoidal instead of straight. In the ordinary block the blanks are straight, following the rectilinear elements of the cylindrical block.

The segments of these breech screws are cut out following helices instead of being straight.

This helical arrangement allows the movements of rotation and translation of the block to be given by a single circular movement imparted to the handle in a plane perpendicular to the axis of the piece.

Two of the helicoidal blanks have a helicoidal groove following their middle elements in which move friction rollers imbedded in the carrier ring. The rotation of the block one-eighth of a turn, or 45 degrees, frees the threaded segments from their corresponding segments in the nut. During this time the friction rollers pass over a straight portion of the groove; then, continuing the motion of rotation, the fixed rollers engage in the helicoidal part of the grooves and impart a motion of translation to the breech screw in the direction of its axis until it is withdrawn from the gun. The breech is closed by an inverse motion.

The breech screw has a plastic obturator. The piece is fired by a percussion obturating primer, detonated by the bolt hammer.

The hammer is cocked by raising the lever handle, and at the same time the empty primer is automatically extracted.

A special arrangement keeps the lever from falling down and the hammer from striking the primer before the complete fermeture of the breech. This prevents premature firing.

The manipulation is easy and rapid and with field or mountain guns would accelerate their rapidity of fire.

The mortar has a special carriage with brake and elastic braces. This carriage has the general form of a disappearing carriage, composed of a counterpoised lever oscillating around a horizontal pivot borne by the rotating platform. This platform, through the interposition of a crown of friction rollers, rests upon a fixed saddle or bolster.

At the lower end of the counterpoise lever is a slot in which is inserted a trunnion cast on the horizontal brake cylinder. The piston rod of this cylinder is fastened to the front of the rotating platform. This is the recoil brake. The return in battery is spontaneously effected by springs.

The carriage is designed to diminish as much as possible the reactions upon the mortar trunnions. With this object in view a heavy gutta-percha sleeve is placed upon the pivot of the counterpoised lever which serves as the axis of rotation of the oscillating system. By this means the reaction of the piece is considerably reduced and the shock to the decks of vessels is not great.

The piece is supported in front of the trunnions by a connecting rod articulated to the end of an arm forming part of a sleeve or coupling box. The piece is elevated by a lever inserted in a socket of the sleeve. The sleeve is fixed by a set screw. The piece is traversed by a lever and held at the desired angle by a clamp.

This is a very simple system, light and easy to work, and produces comparatively little shock on the decks of vessels.

The carriage is valuable for use in curved fire.

The howitzer is mounted on a counterpoised carriage with circular brake lodged in the pivot of the counterpoise lever.

The piece maintains a constant angle with its counterpoise lever, which permits firing at all angles without difficulty in loading or very perceptible changes in the effort required to maneuver the piece.

(12) Canet circular chassis carriage for 140-millimeter (5.51-inch) naval gun.

(Plate XXXIV.)

This is a special model. The gun is embedded in a carriage A that carries the brake cylinders and the spring accumulator. The chassis B has a fixed and a movable part.

The movable part is composed of two flasks, connected by transoms, which have the form of a large circular segment whose chord serves as recoil guides for the carriage.

The piston rods of the brakes bear upon the circular guides of the fixed part, D, of the chassis through the interposition of a kind of guide block, C, furnished with friction rollers. The fixed part also carries two flasks mounted on a horizontal platform which rests upon a crown of friction rollers supported on the bolster saddle E.

The axis of the brake cylinders remaining constantly in the same plane as that of the gun, and the resistance being always directly opposed to the effort of recoil, the couple which tends to upset the gun and the reactions upon the carriage are much diminished.

The spring accumulator returns the gun in battery.

The French navy has ordered several of these carriages, which are designed to diminish the shock on the decks.

(13) Canet horizontal chassis carriage for 140-millimeter (5.51-inch) naval gun.

This type also is designed to protect the decks of vessels from excessive shocks in firing, which increase with the inclination of the chassis rails. In this case the guide plates are horizontal. The return in battery is effected by a spring accumulator.

This type of carriage is intended for light vessels.

(14) Canet 120-millimeter (4.72-inch) siege and garrison guns on hydraulic-brake carriages.

(Plates XXXV and XXXVa.)

These two high-power guns have the breech fitted with a special safety device. It consists in a bolt carrying an arm that covers the vent. The latter remains covered during the whole time of working the breech, and it is only when the handle is lowered that the bolt rises and a primer can be inserted.

There are no cavities or lodging places on the face of the breech to get filled with dust and sand and render the manipulation difficult.

These guns are mounted on steel-plate carriages solidly braced by transoms.

The wheels may be chocked by means of shoes.

To reduce the recoil, fasten an hydraulic brake, attached to the flasks, to the front of the gun platform. In recoiling the carriage mounts two inclined planes made of steel and returns in battery under the influence of gravity. The inclined planes have a flange designed to guide the felloes of the wheels, and are joined by a traverse forming part of the pivot.

The traversing is done with levers, the carriage turning with its inclined planes around the front pivot. Between the axle and the

connecting pieces on the flask is interposed a heavy rubber sleeve to diminish the shock in firing.

	Metric.	English.
Weight of piece	1,430 kilograms	3,152.5 pounds.
Weight of projectile	18 kilograms	39.7 pounds.
Weight of powder charge	4.6 kilograms	10.1 pounds.
Total weight of carriage	1,650 kilograms	3,637.6 pounds.
Initial velocity	520 meters	1,706 feet.
Thickness of wrought iron perforated:		
At the muzzle	0.190 meters	7.48 inches.
At 1,000 meters	0.140 meters	5.51 inches.
At 2,000 meters	0.110 meters	4.33 inches.
Maximum range	9,000 meters	5.6 miles.

(15) CANET—75-MILLIMETER (2.95-INCH) FIELD AND MOUNTAIN GUN.

There are two types of field guns; one long, the other short. All three have a uniform caliber in order to use the same ammunition. By reducing the caliber to 75 millimeters Mr. Canet gets the necessary lightness without a great sacrifice of power.

LONG FIELD GUN.

	Metric.	English.
Weight of piece	359.0 kilograms	791.5 pounds.
Weight of projectile	5.2 kilograms	11.46 pounds.
Weight of powder charge	1.5 kilograms	3.31 pounds.
Total weight of carriage	490.0 kilograms	1,080.27 pounds.
Initial velocity	550 meters	1,804.5 feet.
Maximum range	8,400 meters	5.22 miles.

SHORT FIELD GUN.

Weight of piece	263.0 kilograms	579.81 pounds.
Weight of projectile	5.2 kilograms	11.46 pounds.
Weight of powder charge	1.0 kilogram	2.20 pounds.
Total weight of carriage	390.0 kilograms	859.81 pounds.
Initial velocity	430 meters	1,410.8 feet.
Maximum range	7,600 meters	4.72 miles.

MOUNTAIN GUN.

Weight of piece	100.0 kilograms	220.46 pounds.
Weight of projectile	5.2 kilograms	11.46 pounds.
Weight of powder charge	0.5 kilogram	1.10 pounds.
Total weight of carriage	140.0 kilograms	308.64 pounds.
Initial velocity	305 meters	1,000 feet.
Maximum range	6.000 meters	3.73 miles.

Each of these guns has its own special fermeture and safety device to prevent premature discharge.

The carriages are formed of two flasks punched out of steel plates and connected by cast-steel transoms. This method of construction dispenses with the forging of the flasks and with a part of the riveting. The wheels are made of steel with a bronze nave; the oiling is automatic and continuous.

The mountain carriage has a brake at the end of the axle; the long field gun is mounted on an elastic hydraulic-brake carriage, with recoil brake placed eccentrically, the short field gun is on a carriage with a Lemoine brake.

The Canet eccentric and hydraulic recoil brakes on carriage for long field gun.

(Plates XXXVI and XXXVIa.)

In his long field gun, Mr. Canet has an arrangement which allows the flasks of the carriage to rotate slightly about the axle in order to ease the strain on the latter in firing.

The carriage has two flasks united by transoms. It sustains the gun by the trunnions, but is not fastened directly to the axle, as is customary; it is connected with the latter by means of a combination hydraulic and spring brake inclosed in a cylinder jointed in a chape carried by one of the transoms. The springs are held between the cover of the cylindrical box and a perforated piston with variable orifices whose piston-rod, terminated by a ring, is mounted upon the axle.

Two oscillating arms upon the axle carry a trunnion that joins these arms to the body of the carriage, allowing the latter, however, a movement of oscillation about the axis of the axle.

A special arrangement allows a suitable initial tension to be given to the springs.

At the instant of firing, the gun recoils and carries the carriage to the rear; the arms oscillate upon the axle, the brake cylinder following the movement of the carriage. The brake then acts, diminishes the shock of recoil, and the axle is not violently jerked to the rear as in ordinary carriages. The gun is arrested, the springs resume their initial tension, and carry the gun back in battery.

The shock of return is avoided by interposing an elastic buffer fastened under the piston.

Thus the action of firing is appreciably weakened, and it becomes possible to put higher-powered guns upon much lighter carriages without having any fears as to their resistance or endurance under ordinary service conditions.

To preserve the elevating gear from the effects of shock in firing, which tends to injure the mechanism, Mr. Canet employs an elastic system with a certain vertical displacement. This system may be

varied according to the arrangments of the mechanism, and be applied to all pointing apparatus.

In the carriage exhibited, the pointing gear consists of a lever joined to the middle or pointing transom by an intermediate elastic connecting rod. This lever carries an oscillating screw nut which permits the working of the system by a screw and crank. The connecting rod that supports the gun is a hollow cylinder, encasing two sets of springs resting on a partition formed toward the middle of the cylinder. The gun is fastened to this connecting rod by a joint forming the head of a rod upon which the springs are mounted, the initial compression of the latter being given by the nut terminating the rod.

This system reduces notably the shock upon the mechanism.

The eccentric brake is composed of a shoe fastened to the extremity of a rod. This rod is jointed to a connecting rod attached to the axle at one end, and at its other extremity is held by a chain which is caught up on the flasks. When the chain is hooked up the shoe is raised and does not act; when the chain is hanging down the shoe falls upon the felloe by its own weight.

In recoiling, the point around which the rod pivots being eccentric with reference to the axis of the wheel, the shoe is applied against the felloe and exerts a strong grip.

The brake gear is so arranged as to permit of its use during the march; the connecting rod, with springs which supports the gun, is chocked upon the cross-bar of the flasks, which eases the elevating apparatus. Lower the pointing lever, to which is fastened the rod of the shoe by means of a key-bolt; then press on the pointing lever in order to clasp the shoe upon the wheel more or less strongly, just as with an ordinary carriage brake.

THE LEMOINE BRAKE.

(Plates XXXVII and XXXVIIa.)

The short 75-millimeter Canet field gun has the Lemoine rope brake adopted by the French artillery.

This brake has been modified by Mr. Canet to adapt it to his carriages.

The brake consists of two battens, *a a*, at the ends of two connecting rods, *b b*, fastened to the flasks of the carriage. At the end of this flying brake is pivoted an elbowed rod, *c*, carried by a collar, *d*, embracing the axle. To this rod is attached a rope, *e*, which is coiled around the interior end of the bronze nave of the wheel, from below upwards. These ropes take two turns and then are fastened to the ends of a kind of swingletree, *f*.

This swingletree is a flexible rod held in the middle by a short rod, *g*, parallel to the flasks. This short rod is movable and is guided at its end by a sleeve. On the front end it has a hand loop, *h*, and on

one of the lateral faces a series of teeth. A spring presses the rod and holds the teeth against some notches cut in the guides.

If the swingletree is drawn away from the axle, by any means, it pulls upon the ends of the cord.

Ordinarily the axle turns without pulling the cord, but as soon as any traction is applied to the end of the cord it binds upon the hub. If the wheel move backward in recoil it pulls upon the cord, which is wound upon the nave and applies an energetic pressure of the battens upon the felloes of the wheels.

The motion of the swingletree to the front is determined in two ways :

(1) *On the march.*—If it be desired to put on the brake, draw the rod *g* by the handle to the rear and put it at a suitable notch. When the carriage starts the brake acts.

(2) *In firing.*—The carriage recoils sharply ; the rod *g*, which is suitably ballasted by the additional weight *p*, remains motionless from its inertia.

The axle is displaced with respect to the swing-bar, the cord is tightened upon the nave, and the brake acts at once. When the piece is run forward in battery the brake is loosened.

This is an automatic brake, and is said to work well in practice.

Experiments with the Lemoine brake in Spain.

[Cited by Lieut. Malengreau from Revue d'Artillerie, June, 1889.]

ON 9-CENTIMETER FIELD-CARRIAGE, MODEL, 1878.

Twenty rounds with shell and regulation charges, twelve on natural soil, and eight on stone platform.

	Metric.	English.
On natural soil :		
Adjusting round, recoil	1.90 meters	6.23 feet.
Six rounds, mean recoil	0.88 meter	2.89 feet.
Three rounds, brake off, recoil	3.06 meters	10.04 feet.
Two rounds, slope favorable, recoil	0.77 meter	2.53 feet.
On stone platform :		
Three rounds, brake off, mean recoil	8.70 meters	28.54 feet.
Five rounds, brake on, mean recoil	1,78 meters	5.84 feet.
Result :		
On natural soil, recoil reduced to one-fourth		
On stone platform, recoil reduced to one-fifth		

ON 12-CENTIMETER SIEGE-CARRIAGE, MODEL, 1881.

Fourteen rounds with shell and regulation charges, on wooden platform.

	Metric.	English.
One round, brake off, free recoil	3.70 meters	12.14 feet.
Two rounds, adjusting brake, each recoil	2.90 meters	9.51 feet.
Eleven rounds, brake on, mean recoil	1.89 meters	6.20 feet.

16) CANET 100, 120, AND 150 MILLIMETER (3.94, 4.72, AND 5.90 INCH) RAPID-FIRING GUNS.

(Plate XXXVIII.)

These guns are designed not only for defense against torpedo boats and auxiliary armament, but for the armament of light vessels to contend with armored ships. The armament is to be supplemented by 47 and 57 millimeter guns, mitrailleuses, and revolving cannon.

100-MILLIMETER (3.94-INCH) RAPID-FIRING GUN.

	Metric.	English.
Weight of gun	2,100 kilograms	4,629.7 pounds.
Weight of projectile	13 kilograms	28.66 pounds.
Weight of powder charge	6.5 kilograms	14.33 pounds.
Total weight of carriage	1,860 kilograms	4,100.60 pounds.
Initial velocity	760 meters	2,493.5 f. s.
Thickness of wrought-iron plate perforated:		
At muzzle	0.220 meter	8.66 inches.
At 1,000 meters	0.170 meter	6.69 inches.
At 2,000 meters	0.130 meter	5.12 inches.

120-MILLIMETER (4.72-INCH) RAPID-FIRING GUN.

Weight of gun	3,300 kilograms	7,275.3 pounds.
Weight of projectile	21 kilograms	46.3 pounds.
Weight of powder charge	10.5 kilograms	23.15 pounds.
Total weight of carriage	3,300 kilograms	7,275.30 pounds.
Initial velocity	760 meters	2,493.5 f. s.
Thickness of wrought-iron plate perforated:		
At muzzle	0.270 meter	10.63 inches.
At 1,000 meters	0.210 meter	8.27 inches.
At 2,000 meters	0.170 meter	6.69 inches.

150-MILLIMETER (5.9-INCH) RAPID-FIRING GUN.

Weight of gun	6,400 kilograms	14,109.5 pounds.
Weight of projectile	40 kilograms	88.18 pounds.
Weight of powder charge	20 kilograms	44.09 pounds.
Total weight of carriage	4,700 kilograms	10,361.70 pounds.
Initial velocity	760 meters	2,493.5 f. s.
Thickness of wrought-iron plate perforated:		
At muzzle	0.360 meter	14.17 inches.
At 1,000 meters	0.300 meter	11.81 inches.
At 2,000 meters	0.250 meter	9.84 inches.

There are two types of each of these guns; one long, 48 calibers in length; one short, 35 calibers in length.

The breech mechanism is the interrupted screw in all cases, as in the larger calibers the breechblock is quite heavy.

AUTOMATIC OPENING OF THE BREECH (CANET SYSTEM).

In some types of rapid-firing guns the automatic opening of the breech is produced during the recoil of the gun. In this arrangement the breech screw may be disengaged from its screw box when the gas pressure is high enough to project the screw or cartridge shell to the rear and cause accidents.

In the Canet system the breech is opened as the gun returns in battery. In this way the above class of accidents is entirely avoided. When the gun returns to its firing position the only thing remaining to be done is to remove the partially extracted shell and load again.

Action of automatic system.—At a fixed point of the carriage, is jointed at one of its ends a long, hollow tube placed horizontally and nearly parallel to the axis of the piece; it is held at its middle point by an arm carried by the carriage. In this tube is a rod which is attached to a striking lever movable about an axis fixed to the rear of the gun.

A spiral spring, encased in the tube, presses constantly upon a plug or disk carried by the rod near its front end, and presses the striking lever against a stop placed on the gun at the height of the face of the breech.

At the instant of firing, the striking lever follows the shifting of the gun and drags away the interior rod whose spring acts to press it constantly against the eyebolt of the gun. During this period, the tube remains fixed.

After recoiling, the gun returning in battery carries back towards the front the maneuvering arm and the interior rod. At a certain moment the plug-disk of the movable rod meets a spring-pawl which had fallen in place immediately after its passage during recoil.

At this moment the rod becomes immovable, like the tube, and the gun continues to return in battery, carrying along with it the axis of the striking lever, while the other end of this arm is held firmly by the now immovable rod. This striking lever then pivots around its axis, acting upon an arm mounted upon the same axis as the maneuvering lever of the breech.

The effect, therefore, is precisely the same as if one acted upon the maneuvering lever with the hand, and the breech is opened, extracting the empty shell.

Some instants before the return in battery is completed, a stud screwed in the gun strikes a ring which it carries toward the front. This ring presses down the tail of the stop or pawl, which oscillates. The spiral spring then acts upon the plug-disk, and the rod carried back toward the front drags along the striking lever until it reaches its primitive position. A small spring also carries back the ring to its first position.

The closing of the breech is done by hand, and the piece is again ready for firing.

METHOD OF WORKING THE GUN.

The chief of piece first assures himself that everything is in good order and ready for firing.

The gunner places himself in position on the left side of the carriage, his eye in the prolongation of the line of sight, seizes the traversing lever with his right hand and the elevating wheel with his left, and then follows the movable or fixed target without disturbing himself about anything except aiming.

The cannoneers placed behind him about 1.5 meters (5 feet) busy themselves with the loading and firing. For the first round, they open the breech by hand, load the piece, and close it again. The gun is fired by pressing the button closing the electric circuit. The gun recoils; on its return in battery, the breech is opened automatically and the shell partially withdrawn. A cannoneer seizes the latter and carries it away, another inserts a cartridge, and a third on the right closes the breech by simply pulling the lever from left to right.

All this time the gunner has not ceased to follow the target without being incommoded in any way whatever, either by the firing, since the sleeve acting as a brake cylinder remains fixed, or by the cannoneers, who are sufficiently removed to avoid disturbing him.

The 100-millimeter gun can be fired ten to twelve rounds per minute by well-drilled men.

AMMUNITION.

Projectiles.—There are four kinds of projectiles for the rapid-firing guns:

(1) Armor-piercing steel shell with interior charge.

(2) Common cast-iron shell with bursting charge and percussion fuse.

(3) Case shot, filled with hardened lead bullets, with bursting charge and combination time and percussion fuse.

(4) Canister, with zinc envelope and wooden sabot.

All these projectiles have a copper band for rotating, except the last.

Cartridge shells.—These are brass. The design has been carefully studied to obtain perfect obturation and to avoid swelling in firing. The base of the shell is armed with an electric primer whose central wire is carefully pickled to remove scale and whose end is cleaned to make the circuit unerringly. There is no fulminate or detonating substance to explode by accidental shocks.

The projectile and charge being united are introduced in the bore at the same time, without the necessity of sponging.

The obturation being good, the chamber does not have to be washed our after every shot.

(17) Carriages for Canet rapid-firing guns.

With high-power guns all recoil can not be suppressed, hence all efforts are bent towards producing carriages with limited recoil produced by the action of hydraulic or other brakes.

1. CARRIAGE FOR 100-MILLIMETER (3.94-INCH) GUN.

The gun is held in a cylinder connected with the chassis by trunnions and serving as an hydraulic brake cylinder. The gun carries a flange which acts as a piston for the brake. During the recoil, whose length is 350 millimeters (13.78 inches), the liquid filling the space left free between the gun and cylinder passes from the rear of the flange or piston to the front, through the play allowed between the piston and the wall of the cylinder. The profile of this wall has been studied in detail to secure, if possible, at each instant, an escape varying according to the intensity of the recoil, in order to have a constant resistance and not fatigue the carriage.

The liquid driven out, due to the difference between the diameter of the gun in front and in rear of the piston, raises a spring valve and flows into a cylinder. A plunger enters this cylinder, which is loaded by springs abutting against a cross-bar mounted on the chassis.

When the recoil is terminated the liquid is pressed back, reënters the cylinder by a small hole in the valve, and slowly returns the gun in battery.

It is during this return that the breech is opened, as has been stated previously.

The arrangement of the brake is such that the carriage can be absolutely fixed upon the chassis in heavy seas. The chassis rests on a bolster, with the interposition of a crown of conical friction rollers. The part in front of the chassis is protected by a fender, and the chassis carries an inclined trunconical shield which protects it from the front and sides.

The brake cylinder has on its left side a toothed sector for elevating the piece, engaging a pinion worked by a special apparatus mounted on the flask of the chassis. This pointing apparatus, formed by an eccentric training-wheel, acts on a pinion engaging a second pinion with interior teeth and connected with the maneuvering apparatus by friction cones. These latter prevent the transmission of the vibrations of the gun to the pointing gear.

The special arrangement of the gear permits of great rapidity of handling, as little effort is required to operate it.

The traversing is done by a hand lever mounted on the chassis platform, and which has at its lower end a spring brake acting on the

bolster. In pointing, it is sufficient to press slightly on the upper end of the lever and traverse the whole system by carrying the lever to the right or left. Removing the pressure on the lever, the brake acts and holds the carriage in its position.

2. CARRIAGE FOR 120-MILLIMETER (4.72-INCH) GUN.

This is a cradle in which the gun is imbedded. This cradle carries the brake-cylinders, whose axes are at the same height as that of the gun, in order to diminish the moment of the couple tending to rotate the gun in a vertical plane. The piston rods are attached in front to a horizontal pivot on the chassis and around which the whole system rotates. The general outline of the chassis is bell-shaped.

The gun is run in battery by a special spring accumulator, which carries it back with a very slight movement given to the springs. The accumulator is seated in the carriage.

The piece is elevated by a handwheel, which, keyed to an arbor, acts on a pinion engaging two toothed sectors on the chassis.

The traversing is done either with a hand lever or the ordinary traversing gear.

3. CARRIAGE FOR 150-MILLIMETER (5.9-INCH) GUN.

This carriage has a horizontal chassis. The gun is held in the trunnions in the carriage which carries the brake cylinders and the spring accumulator. This carriage recoils along the horizontal guide rails of the chassis, furnished with friction rollers.

The chassis rests on the bolster by the interposition of spheres.

NOTES ON THE GUN FACTORY AT HAVRE.

The gun factory proper covers 7,182 square meters.

The motive power is furnished by two compound marine engines, which may be coupled or run singly. The nominal force is 80 horse-power each, but they can develop 120 horse-power. Normal speed, ninety turns per minute.

Three Galloway boilers generate the steam. Two in use and one in reserve.

The main shaft is parallel to the axis of the shops. Two large pulleys, placed one on each side of the fly wheel, carry the driving belts to run the five lines of shafting.

Hoisting cranes.—Several are used. There are two in the main nave—traveling cranes—one 30-ton and one 60-ton, but geared to work together and hoist 90 tons. Seven-ton, 10-ton and 30-ton cranes are used in various parts of the works, depending on the material to be handled.

Shrinking pits.—This well is 8 meters (26.25 feet) deep and 2.5 meters (8.2 feet) in diameter. Heating is done by gas. Several small

pits are prepared for lighter work. Beside the large pit is the large grinding plate, 5 meters (16.4 feet) by 2.5 meters (8.2 feet).

Electric lighting.—General—arranged for night work, arc lamps reflectors; incandescent lamps for delicate work. A Parsons and high-speed motor runs the dynamo. Gas is also provided for lighting in case of necessity.

Machines.—Ten large lathes, handling pieces 12 to 14 meters (39 to 46 feet) long and weighing 60 to 100 tons. Two large rifling machines for naval guns. Twenty medium lathes for pieces 6 to 10 meters (20 to 33 feet) long, weighing 10 to 20 tons. Two rifling machines for same guns. Five large machines for cutting threads and counter-sinking. Fifty machines for cutting threads, counter-sinking, boring and slotting. Fifty lathes for guns of small caliber and for projectiles. These are only the heavier machines.

Testing machine for metals.—This is the system of Col. Maillard furnished with the differential manometer of Galy-Cazalat. This has been adopted for the marine laboratory. Tests for traction, compression, and bending can be made on the machine. Elongations are measured by a horizontal cathetometer reading to the hundredth of a millimeter.

Boring and turning.—Variations allowed, one one-hundredth of a millimeter, nearly, or about four ten-thousandths of an inch.

The shrinkage varies according to the case, but the mean is about one seven-hundredth or 1.42 thousandths to the inch. Heating is done by special gas furnaces. Jackets and hoops are heated to a blue.

The hooping is done vertically and the joints are secured by cooling and nipping the bottom edge first.

The proof firing consists of eight rounds, with various charges, to get velocities and see the action of the mechanism and carriages.

On the firing ground, the velocities are taken simultaneously by two Le Boulangé-Bréger chronographs.

Crusher gauges are used for pressures. Col. Sebert's velocimeter is used to get velocities of recoil, to determine all the details of the action of carriages and guns, pressure in the brake cylinders, length and diameter of recoils, delays in inflammation of powder, time of travel of projectile in the bore, etc.

The Sebert flectographs verify the movements of springing and the vibrations of bolster-saddles, chassis, and platforms.

The total output to date is about 2,000 guns, 1,600 carriages of all kinds, and 100 torpedo tubes.

CHAPTER VIII.

THE MAXIM-NORDENFELDT GUNS.

The Maxim gun and the Nordenfeldt gun companies were consolidated in 1888 under the title of "The Maxim-Nordenfeldt Guns and Ammunitions Company." The company made two exhibits, one in the English section, the other in the French section.

The Nordenfeldt guns are adopted in the English navy.

The Italian navy has adopted the 57-millimeter rapid-firing Nordenfeldt gun. It is mounted similarly to the Hotchkiss gun. It fires three different kinds of projectiles:

(1) A steel shell with base percussion fuse.

(2) A steel shrapnel with a combination time and percussion nose fuse.

(3) A canister shot.

NORDENFELDT RAPID-FIRING GUNS.

These are all-steel guns and possess essentially the same breech mechanism.

DESCRIPTION OF BREECH MECHANISM.

(Plate XLI.)

The principal parts of the breech-closing device are: (1) Breech block, (2) wedge, (3) lever and cam, (4) directing cam, (5) hammer, (6) main-spring, (7) trigger and sear, (8) extractor, and (9) extractor lever.

(1) *Breech block.*—The block A presses against and sustains the cartridge in firing. There is a vertical undercut or dovetailed fillet on the rear face of the block, which slides in a corresponding groove in the front face of the wedge. At the lower end of the rear face is a square seat, M, for the mainspring H. A cavity is cut for the hammer and the sear. The latter rotates around the pivot L, which is carried by the block. There is a shoulder on the upper end of the block which catches on a corresponding notch in the breech when the block is opened. At the lower end of the block is cylindrical hole for a the arbor D of the lever.

(2) *The wedge.*—The wedge, B, is immediately in rear of the breech block and is connected with it by the dovetailed groove and fillet above mentioned.

This arrangement enables the block and wedge to slide over each other in a longitudinal direction for a certain distance without moving the block, which is then drawn away from the breech face of the piece in opening.

There is a cylindrical tenon at the lower end of the wedge, which moves in the curved slot of the directing cam F. The hammer is cocked by the downward motion of the wedge. An inclined plane on the latter engages the projections on the hammer and draws it to the rear until the sear nose falls into its notch. This action compresses the mainspring at the same time.

(3) *The lever and cam.*—This lever, C, opens and closes the breech mechanism. It is keyed to the axis D, which is attached to the breech block. When the lever is pulled back to open the breech the cam strikes against the exterior branch of the extractor lever and causes it to rotate around its axis.

(4) *Directing cam.*—This cam, F, is fastened to the lever pivot and moves with it. The cam slot at its front end is circular for a short distance and then is nearly straight for the rest of its length. The circular part is concentric with the pivot axis. It has a salient intended to strike the detent and fire the piece.

(5) *The detonating hammer.*—The hammer, G, is situated in the cavity in the breech block and its ears act against the inclined plane of the breech block.

(6) *The mainspring.*—This is a flat curved spring, which is fastened to the lower end of the breech block.

(7) *The trigger and sear.*—This piece, I, is hinged to the block by the pivot L and has a safety catch.

(8) *The extractor.*—This has two arms, each ending in a hook and connected by a horizontal cylinder, which rotates around the axis. The extractor lever is fastened to the end of this connecting cylinder and is in a plane perpendicular to the axis.

ACTION OF MECHANISM.

Start with the breech closed. The lever is then turned towards the front. Draw the lever back. The tenon of the wedge first passes over the circular part of the cam slot F and gives no movement to the mechanism, but as soon as it passes into the straight part of the slot the wedge A slides downward. This motion brings the inclined plane of the wedge against the ears of the hammer G and draws it back, compressing the mainspring. As the lever is carried back the wedge strikes the trigger and makes it rotate until the sear hook catches in the notch of the hammer.

When the tenon arrives at the end of the slot the wedge will rotate around the axis, carrying the block with it, and the breech is open ready for loading. At the same time the lever cam strikes the extractor lever, rotates it towards the rear, which movement carries

the extractor also to the rear, pulling out the empty shell and projecting it to the rear.

Insert the cartridge and reverse the lever, which will close the block. In closing, the block strikes the extractor claws and rotates them back into their cavities. Just as the breech is closed the salient on the directing cam strikes the trigger and fires the piece. There is a contrivance to prevent the cam from striking the detent; in this case the piece is fired by pulling the trigger.

REMARKS.

The mechanism is very simple; there is only one spring. It is solid without being heavy, and can not be fired without the breech being closed.

The cartridge is its own obturator and is pushed home, if not already there, by the block in closing.

The mounting, cleaning, and assembling are easily performed. The pieces are made interchangeable. The rifling in the small calibers is helicoidal and with increasing twist for calibers above 47 millimeters.

AMMUNITION.

The projectiles are common shell, tempered-steel shell, canister, and shrapnel.

The charge is in one piece; the cartridge case carrying the primer and charge has the projectile inserted in its front end. These cases are made of brass and it is claimed that they can be reloaded ten to twelve times.

FUSES.

Two fuses are used with the shrapnel. They are combination time and percussion fuses. The first or Försen fuse is the invention of Lieut. Försen, of the Swedish navy. It dates from 1885. At the instant of firing the fulminating cap strikes on the top of the friction primer, which explodes the cap and sets fire to the fuse composition, which in turn ignites the fine powder in the canal leading to the interior of the shell. There is a disk to set the fuse to the proper time of burning. To make it a percussion fuse, perforate the fuse at a point corresponding to a time longer than the trajectory.

When the projectile strikes, the exploded cap and the case of the friction primer are forced down on the serrated wire of the latter, detonating the primer and communicating the fire to the shell through a channel immediately beneath the friction primer.

The second fuse is similar except that the percussion part is entirely separate from the time fuse.

GUNS EXHIBITED.

(1) Two barrel 1-inch gun on naval carriage. For auxiliary armament of vessels and for boats.

(2) Three barrel rifle-caliber gun on wheeled tripod; mountain service.

(3) Three barrel rifle-caliber gun on cavalry carriage; for service with cavalry.

(4) Five barrel rifle-caliber gun on naval cone. For sweeping decks and repelling boat attacks. Rapidity of fire about six hundred rounds per minute.

(5) Six-pounder light rapid-firing gun (Caponnière). In defense of ditches and for armament of small disappearing turrets. Rapidity of fire said to be thirty-six rounds per minute.

(6) Six-pounder Mark II, on recoil carriage C. For vessels and forts.

(7) Three-pounder Mark I, on recoil carriage B. High-power gun for auxiliary armament of ships.

(8) Three-pounder gun on cavalry carriage. Field service with cavalry.

(9) One and one-half inch automatic gun on cone.

(10) Rifle-caliber automatic gun on light field mounting. To accompany infantry in field service.

(11) Six-pounder automatic rapid-firing gun on naval cone mounting. For naval service. (See below.)

(12) Eight-pounder rapid-firing gun on field carriage. For field service.

(13) Three-pounder automatic quick-firing gun on naval mounting. This is similar to No. 11, for use against torpedo boats.

(14) Fourteen-pounder rapid-firing gun on B carriage. High-power gun, said to deliver twenty-two rounds per minute. With this mounting it is designed for armament of light vessels.

THE 6-POUNDER AUTOMATIC RAPID-FIRING GUN ON NAVAL CONE MOUNTING.

(Plate XLII.)

This gun is apparently an adaptation of the Maxim automatic action to the Nordenfeldt gun. The gun is made from a single piece of steel. It rests in a cradle carrying the trunnions. The cradle is connected with a combined spring and hydraulic buffer which is placed below it. The piston rod is attached to the gun. The breech-block moves vertically. The pistol grip carries the trigger. On the right side is a lever that can raise and lower the block. The lever can be removed. The spring mechanism which operates the block and extractor is on one side. When fired the gun recoils, compressing the spiral buffer spring, which returns the gun to the firing posi-

tion by its reaction. This return action actuates the mechanism in the side box to bring down the block with an increasing velocity which ejects the shell forcibly. When the new cartridge is entered the block closes automatically. The gun may be fired either by pulling the trigger, or, by keeping a pressure on the trigger the gun will fire itself as soon as the breech is closed. The writer is indebted to the Engineer (London), for the cut of this gun and mounting.

THE MAXIM AUTOMATIC GUN.

(Plate XLIII.)

The mechanism of this mitrailleuse is something novel and entirely different from that of all other machine guns.

In this arm, the force of recoil is employed to extract the empty shell, to load a new one in the chamber and to fire it. Everything is done automatically and the piece is fired without stopping until the magazine belt is empty. The gunner has simply to keep the firing-button pressed down.

DESCRIPTION.

The principal parts of the Maxim gun are:

(1) The movable part consisting of (1) The barrel. (2) The lock or firing mechanism. (3) The connecting rod with handle. (4) The arm. (5) The recurved lever. (6) The carrier. (7) The interior frame.

(2) The fixed part consisting of:

(1) The water casing. (2) The breech casing. (3) The safety catch. (4) The abutting lever.

(1) *The moveable part.*—The moveable part is the principal feature of this arm and is in itself really the gun. It is the portion that recoils at the instant of firing. The fixed part merely serves as a support for the movable portion and is not affected by the recoil.

The barrel.—This is an ordinary rifle barrel fastened at its rear end by a dovetail to two steel brackets which are fastened at their ends.

The lock mechanism.—This consists of a firing bolt, a tumbler, and a sear with its spring.

The connecting rod with handle or lever.—The lock is attached by a screw with interrupted threads to a connecting rod fastened to a lever or handle whose axis passes through the two brackets. The adoption of the interrupted screw enables the lock to be dismounted and replaced in a few seconds. A small hook attached to the movable frame supports the connecting rod and facilitates the removal of the lock.

The axis of the connecting rod extends beyond the right-hand side of the casing and carries the arm F and the recurved lever B.

The carrier.—The carrier D is in front of the lock mechanism and embraces the discharger and extractor. By its recoil with the movable part, and by a vertical movement transmitted to it by a special arrangement, the carrier extracts the empty shell which it pushes into the discharge tube, and engages a new cartridge which it places before the chamber. The carrier has spring hooks which grasp the new cartridge and the empty shell as will be seen later.

(2) *The fixed part.*—The fixed part incloses the movable part. The latter is so adjusted that the recoil throws it to the rear about 25 millimeters (0.98 inch), or about 1 inch. The water case and breech case are rigidly attached by dovetailing. The fixed part is mounted on trunnions and has two handles at the rear end for pointing the gun in any direction. Between the two handles is placed a double firing button, so placed that the two thumbs of the gunner can press upon them. This button is placed at the upper end of a small lever, which acts upon a rod, S, that commands the sear. If the button be pressed the rod S is moved backwards, its bearing part catches the lower part of the sear, the tumbler is then disengaged, and the firing bolt is violently thrown forward by the action of the spring and explodes the primer in the cartridge.

A spring, by its contraction, carries back the sear and the rod to their original position.

A safety catch, situated on the rear end of the gun, when lowered, prevents pressure on the button.

The exterior of the fixed part carries the pointing apparatus, the front and rear sights, the abutting lever fastened to the right side, and the stop spring.

On the left side of the breech case is a long case inclosing a powerful spiral spring designed to bring back the movable part to the firing position after each shot.

The barrel case or water envelope is bronze filled with water, so arranged that the steam from the heated water may pass off freely. In rapid firing the barrels of machine guns heat rapidly and in many cases are deformed unless some special precautions are taken to obviate this difficulty.

There is a tube in the water case in which slides freely a valve. If the piece be aimed above the horizontal plane it glides to rear, closing the water hole at the rear end of the barrel and opening a vent for the steam at the highest part. If the piece be given an angle of depression an inverse action takes place. The ends of the water case are furnished with stuffing boxes, which are held firmly by a spiral spring surrounding the barrel.

The case or reservoir, when filled, requires about five hundred rounds continuous fire to raise the water to boiling, and should lose only about three-fourths of a liter of water from evaporation per one thousand rounds fire.

The abutting lever C is permanently attached to the right side of the breech case.

By reference to Plate XLIII it will be seen that with the breech closed the bent arm B is a certain distance from the lever face. The object of this arrangement is to delay the opening of the breech until the recoil has begun to act. This gives time for the complete combustion of the powder, and avoids the escape of gas by the breech, and the fouling of the chamber. The chamber is not opened until the bullet has left the bore.

The spiral spring on the left side of the breech case is fastened in front to the casing, and at its rear end it is attached to the arbor of the handle by means of a chain and fusee. The rapidity of fire is regulated by the variable force of this spring, which is controlled by an adjusting screw in front.

Feeding device.—The gun is fed by a cartridge belt, which is moved from right to left through the feed slot in the breech and which holds from three hundred to four hundred rounds. The cartridges rest in loops side by side, made from two strips of canvas, connected between the loops by eyelets and thin strips of copper. The front edge of the belt (*i. e.*, the end adjacent to the bullets) is reënforced or thickened by a cord sewed in a fold of canvas, so as to keep the cartridges horizontal, or center them as it were.

The feed slot contains two fixed and two movable pawls or catches. The latter are connected with the barrel by a lever so arranged that the barrel in recoiling moves them from left to right; actuated by a spring they seize the head of the next cartridge in the belt. When the barrel returns after recoil these catches place this cartridge immediately over the chamber.

ACTION OF THE SYSTEM.

Assume the piece ready for firing. The breech is closed by the lock, which is held in place by the connecting rod and the handle. The common axis of these pieces in this position is a little above the horizontal axis of the gun; the breech can be opened only by turning the handle down. Now, this movement of the handle can not be effected by the explosive action of the cartridge.

Hence, when this explosion does take place, it follows that the breech is held firmly closed against the barrel and supports the shock of the recoil of the whole system until the recurved lever B strikes the abutting lever C. This rear movement is about 1 inch.

This sharp stoppage rotates violently the handle; the arm F of the latter is projected against the stop spring H. The curvature of the arm B is so contrived that the arm or manivelle acquires an accelerated motion by means of which the lock is carried to the rear a sufficient distance to insure the extraction (by the carrier D) of the empty shell from the chamber and the extraction of a fresh cartridge

from the feed belt. At the same time the rotation of the arm rolls up the chain of the spiral spring around its fuse, and this spring is placed in a state of tension. In addition to this, while the lock is moving to the rear the carrier D is pressed from above downward by the spring W until it reaches its lowest position, in which the new cartridge is found opposite the mouth of the chamber and the empty shell opposite the ejector tube Q. The vertical motion of the carrier is arrested by a fixed stop when it reaches its lowest position.

In order to hold the cartridges firmly, the carrier is furnished with vertical grooves and movable pieces held in front by springs, and of which the width is equal to the diameter of the cartridge heads. The grooves extend only two-thirds of the length of the carrier.

When the lock, drawn back by the arm, clears the breech of the gun, a projection of the connecting rod B bears, in passing, upon one of the arms of the tumbler G, of which the other arm draws back the firing bolt by compressing the sear spring until the small arm of the sear is engaged in a notch in the tumbler.

The firing bolt is then cocked and can strike the cartridge as soon as the sear is disengaged from the tumbler. In order to avoid firing before the complete fermeture of the breech a safety sear or catch V engages the upper side of the firing bolt during the motion of recoil, and this safety catch permits no forward movement of the bolt before the breech is entirely closed, for it is the front end of the connecting rod which raises the rear end of the spring when the axis of the connecting rod arrives above the horizontal axis of the gun; that is, when the breech is properly closed.

In the second part of the movement the spiral spring brings back the gun and mechanism into its normal firing position; the chain unrolls and draws the arm toward its primitive position.

The lock carried back to the front pushes the new cartridge into the chamber and the empty shell into the ejection tube Q. During the last sixteenth of the forward motion of the lock the carrier D is raised by the lever C, which is itself put in motion by the front portion of the connecting rod.

The carrier is held in its highest position by a spring, so that the center of the cartridge head is directly opposite the point of the firing pin. The carrier being grooved only two-thirds of its length clears itself of the empty shell, which is engaged in the ejection tube Q, where it is held by a spring R to prevent its falling back in the casing when firing at angles of elevation.

In continuous fire the empty shells are carried in turn into the ejector tube, from which they are thrown forcibly by the next blow of the movable breech; at the same time the carrier seizes the head of another cartridge in the feed belt.

The upward motion of the carrier is arrested by a projection on the lock and by the cover of the casing.

If the pressure be relieved from the button immediately after the explosion of a cartridge, the piece will be loaded automatically and be ready for firing. The gun can be fired shot by shot by repeating this quick pressure. It requires some little skill on the part of the gunner to fire the piece by single shots, as a clumsy operator generally fires two or three shots before he can get his thumb off the button.

With a continuous pressure on the button the gun will be loaded and fired automatically without interruption so long as the cartridges in the belt last.

OPERATIONS OF FIRING.

(1) Turn the arm F until its end comes in contact with the stop spring H. This motion draws the lock away from the barrel and feed slot and brings the carrier to its lowest position.

(2) Introduce the feed belt as far as possible into the feed slot, or until the first cartridge comes in contact with the fixed catches of the slot which hold the cartridge in this position.

(3) Free the arm and the spiral spring will return to its normal position and carry forward the breech mechanism. During the last part of this movement the carrier is raised and seizes the head of the cartridge in the belt, which then passes through the feed slot.

(4) Again rotate the arm F to the front until it touches the stop spring H, the lock returns to the rear and the carrier withdraws the cartridge from the belt.

At the end of the rearward motion of the lock the carrier, pressed by the spring W, glides along the inclined planes of the fixed cams M placed upon the interior walls of the casing and carries the first cartridge opposite the chamber.

At the same time push the belt into the feed slot so that the second cartridge comes to its proper place over the chamber.

(5) Let go the arm, which will resume its position in rear; the lock moves forward and forces the first cartridge into the chamber; the carrier in rising glides along the head of this cartridge and seizes the head of the second, which is still in the belt passing through the feed slot.

(6) The gun is now loaded and ready for firing.

(7) Press the button and the firing will proceed automatically as long as there are any cartridges in the belt. Care must be taken that the belt is free to enter the slot.

TO CEASE FIRING AND TO UNLOAD THE PIECE.

(1) Take the thumb off the button. The firing ceases instantly, but the piece is loaded and another cartridge is engaged in the carrier.

(2) Carry the arm to the front. The lock abstracts the cartridge from the bore and withdraws another from the feed belt.

(3) Let the arm come back gently to its primitive position; this throws the first cartridge not fired into the ejector tube and pushes the second into the barrel.

(4) Carry back the arm to the front; this cartridge is extracted from the piece.

(5) Let the arm again return to the rear; the second cartridge is forced into the ejector tube and pushes the first out.

(6) Press the spring placed under the feed slot so as to clear the fixed pawls from the cartridges in the belt; then withdraw the belt from left to right.

Principal weights.

	Kilo-grams.	Pounds.
Mitrailleuse complete with mechanism	22.67	50
Shoulder piece for pointing	7.25	16
Field carriage, with gun complete, feed belt, and four empty ammunition chests	152.3	335.75
Tripod, heavy	31.74	70
Tripod, light	8.61	19
Support for use in tops of vessels	48.06	104
Support for gunwales of vessels	25.40	56
Support for torpedo boats	25.40	56
Support for common boats	25.40	56
Support for naval	27.65	61
Shield	31.74	70
Tool box, complete	10.43	23
Spare lock	0.965	2.1

EMPLOYMENT OF MAXIM GUN.

It is intended for all services demanding the rapidity, the continuity, and the efficiency of musketry fire.

The lightness of the piece and the small emplacement required render it available for small torpedo boats, ship's boats, in the tops and on the gunwales of vessels, and for service in the field with infantry and cavalry.

ADVANTAGES.

(1) Lightness.

(2) Security of cannoneers, as the piece can not be fired until the breech is closed. The firing pin can only strike the cartridge through a hole in the carrier, and this is never opposite the firing pin until the breech is fully closed. Again, the safety sear does not allow the bolt to move forward until the axis of the connecting rod is above the horizontal, and then the breech is completely closed. This, then, is another guaranty of safety.

(3) The breech does not leave the barrel until after the charge is completely burned, hence there is no escape of gas.

(4) The whole mechanism is perfectly screened.

And in comparison with the old forms of mitrailleuses:

(5) In the first place, hang-fires present no danger. In this new system if the cartridge does not explode at once on firing, the gun waits for it, and the breech is never prematurely opened, since the only force used to open it is that furnished by the cartridge itself. Hence, there is no opening of the breech until the charge has exploded. "In other words, the Maxim mitrailleuse is slow with slow cartridges and rapid with quick cartridges."

(6) It is possible to fire a greater number of cartridges per minute than with any other hand machine-gun, unless, perhaps, it be the Gatling gun.

With the five-barrel Gardner gun about three hundred rounds per minute can be fired with safety. It is claimed that the Gatling has been fired eight hundred rounds per minute. According to the inventor, the Maxim automatic gun can fire with perfect safety six hundred rounds per minute.

(7) This gun is independent of the uncertainty of action to which lever or crank guns are subjected from the inexperience of the gunners. The Maxim gun is independent of individual experience in manipulation. The active force is the recoil, which is always the same in all weathers and under all conditions.

(8) It does not require as heavy a support or carriage as other guns, since its aim is not deranged by the turning of cranks or pulling of levers. A light support is cheaper.

(9) In the ordinary gravity feed, it is impossible to prevent a cartridge or shell at some time from catching and clogging the mechanism.

In the Maxim gun the feed belt is claimed to give more guaranty for regular feeding than any other system, and permits of the use of a greater number of cartridges than the usual feed cases or magazines.

(10) The magazine holding the feed belt is under the gun instead of above it.

REMARKS.

The mechanism of this gun appears to be quite complicated. There will probably be some difficulty in adapting it to the rough usage of field service. It is possible that there may be some trouble in its fabrication in quantities.

There are so many fine gauging points, so many spiral springs, and steel wire springs are so variable in their action and temper that the wire will require incessant care to preserve the proper quality. The irregular pieces will be hard to temper without more or less of them becoming distorted or "checked." Notwithstanding the water jacket, it is probable that the number of rounds fired continuously

will be limited, no matter how long the feed belt may be, as the heating will probably be sufficient to embarrass the action of the gun.

The adjustments will require the greatest care, since there are so many interdependent parts.

CHAPTER IX.

THE CAIL WORKS.

[Société Anonyme des Anciens Établissements Cail.]

These works were established in 1812 by MM. Ch. Derosne and J. F. Cail. They took the present name in 1882. The principal shops are in Paris, with two branches, one at Douai and the other at Denain. The celebrated Col. de Bange is the director-general.

During the war of 1870 they established a plant for artillery material, since which time they have turned out the following ordnance for foreign countries, viz: For Mexico, eight field and eight mountain batteries; for Servia, forty-five field and seven mountain batteries; for Costa Rica, one field and two mountain batteries; for Sweden, two field batteries; for Denmark, one 149-millimeter siege gun on carriage with hydraulic brake, and one 8-centimeter rifled mortar; for Brazil, one 179-millimeter navy gun and carriage with hydraulic brake; or a total of four hundred and forty-one guns and four hundred and eighty-nine carriages, besides a large quantity of ordnance and ordnance stores delivered to the French army and navy.

GUNS EXHIBITED BY CAIL WORKS.

80-millimeter mountain gun.
80-millimeter field gun (light).
80-millimeter field gun (regulation French).
120-millimeter siege gun.
155-millimeter siege howitzer.
155-millimeter seacoast and naval gun.
320-millimeter seacoast and naval gun.
57-millimeter Engström rapid-firing gun (light).
57-millimeter Engström rapid-firing gun (heavy).

Also projectiles for all these guns.

(1) MOUNTAIN ARTILLERY.

The gun exhibited has a caliber of 80 millimeters (3.15 inches) and is similar to the service piece in the French land artillery.

Principal dimensions, weights, etc.

	Metric.	English.
Diameter of bore across lands	80 millimeters	3.15 inches.
Diameter of bore to bottom of grooves	81 millimeters	3.19 inches.
Total length of gun (15 calibers)	1,200 millimeters	47.24 inches.
Number of grooves	24	24.
Weight:		
Total of piece	105 kilograms	231.08 pounds.
Of projectile	6 kilograms	13.23 pounds.
Of powder charge	0.4 kilogram	14 ounces.
Initial velocity	250 meters	820 feet.

The carriage is similar to the regulation French mountain carriage but has spring shoe brakes fitted to the wheels to limit the recoil. The material can be transported on the backs of pack mules, or on wheels by means of a pair of shafts. In the first case one mule carries the gun, a second mule the carriage, and a third the wheels and shafts. The ammunition cases, each containing seven rounds, are packed on mules, two cases to each mule.

Principal dimensions, weights, etc.

	Metric.	English.
Height of trunnion above ground	755 millimeters	29.72 inches.
Diameter of wheels	906 millimeters	35.67 inches.
Width of tread (middle of tires)	680 millimeters	26.77 inches.
Weight of carriage without wheels	110 kilograms	242.5 pounds.
Weight of carriage total, with gun	265 kilograms	584.22 pounds.
Angle of recoil	33 degrees	33 degrees.
Limiting angles of fire:		
Elevation	+30 degrees	+30 degrees.
Depression	−12 degrees	−12 degrees.

(2) FIELD ARTILLERY.

These guns have the same caliber, 80 millimeters (3.15 inches), as the mountain gun. The light piece is designed for mountainous regions, the other is the regulation gun of the French army.

(A) 80-MILLIMETER (3.15-INCH) LIGHT FIELD GUN AND CARRIAGE.

This gun is the usual de Bange gun with interrupted screw fermeture.

The carriage is made of sheet steel and is furnished with sliding shoes for going down hill. The limber is entirely of metal; the ammunition chest contains eighteen projectiles in six cases, and twenty cartridges in five leather pouches.

The rear carriage of the caisson only differs from the limber by having the pole replaced by a trail armed with a spindle for the transportation of a spare wheel.

Principal dimensions, weights, etc.

	Metric.	English.
Diameter of bore	80 millimeters	3.15 inches.
Diameter to bottom of grooves	81 millimeters	3.19 inches.
Total length of gun (18.7 calibers)	1,500 millimeters	59.05 inches.
Number of grooves	24	24.
Weight:		
Total of piece	165 kilograms	363.75 pounds.
Of projectile	6 kilograms	13.23 pounds.
Of powder charge	0.5 kilogram	1.10 pounds.
Initial velocity	290 meters	951.5 feet.

Principal dimensions, weights, etc.

	Metric.	English.
Height of trunnions above ground	860 millimeters	33.86 inches.
Diameter of wheels	1,150 millimeters	45.27 inches.
Width of tread (to middle of tires)	1,100 millimeters	43.31 inches.
Weight of carriage	240 kilograms	363.75 pounds.
Weight of carriage loaded with piece	410 kilograms	903.90 pounds.
Angle of recoil	30 degrees	30 degrees.
Limiting angles of fire:		
Elevation	+25 degrees	+25 degrees.
Depression	−10 degrees	−10 degrees.
Weight of limber loaded and equipped	350 kilograms	771.6 pounds.
Weight of caisson loaded and equipped	360 kilograms	793.7 pounds.
Weight of caisson loaded and equipped with spare wheel.	410 kilograms	903.9 pounds.

(B) 80-Millimeter (3.15-inch) field gun and carriage.

The gun is the regulation piece of the French field artillery.

The carriage differs but slightly from the French service carriage. The sponge is removed and is carried under the pole of the limber, and the canister, instead of being on the axle, are placed in the trail box.

The limber is metallic except the pole and wheels.

It is arranged with swingletrees for draft.

The ammunition chest contains thirty projectiles in six cases, and thirty powder charges in six leather pouches. Two drawers carry the accessories and equipments necessary for the service of the piece, as well as the spare parts. The chest also carries some pioneer's tools.

The caisson is also completely metallic. The ammunition chest holds double that of the limber. It is fitted to carry either a spare wheel or spare pole, and some pioneer tools.

Principal dimensions, weights, etc.

	Metric.	English
Diameter of bore	80 millimeters	3.15 inches.
Diameter of bore to bottom of grooves	81 millimeters	3.19 inches.
Total length of piece (25.5 calibers)	2,280 millimeters	89.75 inches.
Number of grooves	24	24.
Weight:		
Of piece, total	425 kilograms	937 pounds.
Of projectile	6.0 kilograms	13.2 pounds.
Of powder charge	1.5 kilograms	3.3 pounds.
Initial velocity	480 meters	1,575 feet.
Height of center of trunnion above the ground	1,060 millimeters	39.6 inches.
Diameter of wheels	1,330 millimeters	52.36 inches.
Width of tread (to middle of tires)	1,425 millimeters	56.10 inches.
Angle of recoil	30 degrees	30 degrees.

Principal dimensions, weights, etc.

	Metric.	English.
Limiting angles of fire:		
Elevation	+25 degrees	+25 degrees.
Depression	−6 degrees	−6 degrees.
Weight—		
Of carriage	535 kilograms	1,179.5 pounds.
Total loaded with piece	955 kilograms	2,105.4 pounds.
Of limber loaded and equipped	705 kilograms	1,554.25 pounds.
Of caisson loaded and equipped	990 kilograms	2,182.6 pounds.
Of caisson loaded and equipped with spare wheel	1,080 kilograms	2,381.0 pounds.

(3) PROJECTILES FOR FIELD AND MOUNTAIN ARTILLERY.

These all have the same caliber for both services, field and mountain guns. The caliber is 80 millimeters (3.15 inches). The projectiles are segment case shot, shrapnel, and canister.

(A) Segment case shot.

This has a body of cast iron, and is armed with a percussion fuse.

	Metric.	English.
Number of balls	23	23.
Weight:		
Of empty shell	5.63 kilograms	12.41 pounds.
Of powder charge	0.15 kilogram	0.33 pound.
Of fuse	0.22 kilogram	0.48 pound.
Total weight	6 kilograms	13.22 pounds.

(B) Shrapnel.

The shrapnel consists of a drawn-steel case filled with hardened lead bullets separated by cast-iron segmental disks. The bursting charge is held in a cast-iron grenade placed in the ogival head. It is armed with a combination time and percussion fuse, burning thirteen seconds, corresponding to a range of 4,000 meters (4,374.5 yards).

Number of lead balls	105
Number of cast-iron segments	36

	Metric.	English.
Weight:		
Shell filled	5.45 kilograms	12.01 pounds.
Powder charge	0.07 kilogram	0.15 pound.
Fuse	0.58 kilogram	1.28 pounds.
Total	6.10 kilograms	13.44 pounds.

(C) CANISTER.

The canister of sheet zinc is filled with hardened lead balls held in position by pouring in melted sulphur.

Number of balls..85
Weight of canister............5.55 kilograms (12.23 pounds)

(4) SIEGE AND POSITION ARTILLERY.

The only pieces exhibited are the 120-millimeter (4.72-inch) gun and 155-millimeter (6.1-inch) howitzer.

(A) 120-MILLIMETER GUN AND CARRIAGE.

These are both of the regulation French model. The carriage is entirely of steel and is supplied with an hydraulic brake.

Principal dimensions, weights, etc.

	Metric.	English.
Diameter of bore	120 millimeters	4.72 inches.
Diameter of bore to bottom of grooves	121.5 millimeters	4.78 inches.
Total length (27 calibers)	3.25 meters	127.95 inches.
Number of grooves	36	36.
Weight—		
of piece, total	1,250 kilograms	2,755.7 pounds.
of projectile	18 kilograms	39.68 pounds.
of powder charge	5 kilograms	11.02 pounds.
Initial velocity	510 meters	1,673 feet.
Height of trunnions above ground	1,800 millimeters	70.87 inches.
Diameter of wheels	1,550 millimeters	61 inches.
Width of tread (middle of wheels)	1,500 millimeters	59.05 inches.
Angle of recoil	33 degrees	33 degrees.
Limiting angles of fire:		
Elevation	+30 degrees	+30 degrees.
Depression	−15 degrees	−15 degrees.
Weight—		
of carriage	1,360 kilograms	3,003.3 pounds.
of hydraulic brake	300 kilograms	661.4 pounds.
total, of carriage and piece	2,910 kilograms	6,415.4 pounds.
of bolster and pintle for moveable platform	930 kilograms	2,050.3 pounds.

(B) 155-MILLIMETER HOWITZER. (CALIBER, 6.1 INCHES.)

This corresponds to the French regulation gun called the 155-millimeter short.

The carriage differs from the corresponding French carriage only in the position of the axle, the arrangement of the friction rollers for running in battery, and the suppression of the false trail. It is a sliding carriage employing wheels only for transportation.

Principal dimensions.

	Metric.	English.
Diameter of bore	155 millimeters	6.10 inches.
Diameter of bore to bottom of grooves	157 millimeters	6.18 inches.
Total length of piece (15.5 calibers)	2,400 millimetrs	94.49 inches.
Number of grooves	48	48.
Weight—		
of piece, total	1,050 kilograms	2,314.8 pounds.
of projectile	40 kilograms	88.2 pounds.
of powder charge	3 kilograms	6.6 pounds.
Initial velocity	300 meters	984,3 feet.
Height of trunnions above ground	1,130 millimeters	44.49 inches.
Length of supporting base	2,160 millimeters	85.04 inches.
Weight of carriage	1,125 kilograms	2,480.2 pounds.

(C) PROJECTILES FOR 120-MILLIMETER (4.72-INCH) GUN.

These are common shell and shrapnel.

(1) *Common shell.*—This shell is made of cast iron and is armed with a percussion fuse.

	Metric.	English.
Weight—		
of shell, empty	17.00 kilograms	27.48 pounds.
of bursting charge	0.81 kilograms	1.78 pounds.
of fuse	0.22 kilograms	0.49 pounds.
Total weight	18.03 kilograms	39.75 pounds.

(2) *Shrapnel.*—The shrapnel consists of a case of drawn sheet steel filled with layers of hardened lead bullets separated by cast-iron segmental disks. The bursting charge is inclosed in the ogival cast-iron head and is armed with a combination time and percussion fuse whose time of burning is thirteen seconds, corresponding to a range of 4,500 meters (4,921.3 yards).

Number of lead balls	252
Number of segments of cast iron	120

	Metric.	English.
Weight—		
of shrapnel, empty	17.44 kilograms	38.45 pounds.
of bursting charge	0.28 kilograms	0.62 pounds.
of fuse	0.58 kilograms	1.27 pounds.
Total weight	18.30 kilograms	40.34 pounds.

(5) MARINE AND SEACOAST ARTILLERY.

The following material was exhibited by the Cail works, viz: A 155-millimeter (6.10-inch) gun on naval carriage; a 270-millimeter

(10.63-inch) mortar and carriage; a 320-millimeter (12.6-inch) gun on seacoast carriage.

(A) 155-MILLIMETER (6.10-INCH) GUN.

(Plates XLIV and XLIV a.)

This is a high-power gun, 35 calibers in length. The ignition of the charge is effected by the gunner, who is stationed behind the piece; hence an obturating primer is necessary. The one employed is the de Bange system which acts by friction and is at the same time a safety device, since the apparatus can not act until the fermeture is closed.

Description of the de Bange obturating primer. (Plate XLV.)—The obturating primer (Figs. 1 and 2) was invented by Col. de Bange in 1884. The head P of the primer is **T**-shaped, flattened in plan. The end of the flattened and serrated wire which ignites the charge is terminated by a short and nearly cylindrical piece, Q.

The safety device (Figs. 3, 4, and 5) comprises a bolt A, borne by the carrier ring, in which it slides, and containing a lever B turning about an axis C fastened upon the bolt A.

The bolt A has two branches, between which is lodged the lever B, connected by forged pieces, one at K, toward the axis of the piece, and the other at its exterior extremity at L, where the maneuvering handle N is attached. In one of the branches is cut a groove, R, terminated by two cavities, E and F, joined to the groove R by two inclined planes.

The groove R receives a stud, G, which is formed by one of the projections of a cylinder constantly pressed toward the exterior by a spiral spring, J, which it incloses. To prevent the turning of the cylinder, a guide H, cast on it, slides in a corresponding groove cut in the cylinder seat. The contact of the stud G and the groove is constantly maintained by the spring, and when the bolt is moved in its slot the stud will follow the groove and fall into the cavities E and F cut out at its extremities to arrest the movement. The groove and cavities are so designed that it requires a certain effort to slide the stud up the incline which unites the groove with the cavity. and while the arrest of motion is positive in one direction there is resistance enough in the other to counteract any tendency to motion due to the movements to which the piece is subjected.

The lever B terminates in a fork, so that when the bolt is pushed toward the center of the piece the exterior end of the igniting wire and the **T**-shaped head of the primer will come to pass between the branches of the fork and be held in an invariable position and at the same time preventing all rotation. If, after engaging the ordinary lanyard in the eyehole D of the lever, an effort be exerted upon the latter, the fork of the lever will catch the head Q of the serrated wire, will carry it away and ignite the primer.

The bolt A passes through a mortise cut in the prolongation of the breech screw. Now, in order that the bolt may be inserted, the fermeture must be completely closed or else the mortise M will not come exactly opposite the end of the bolt. and hence the latter can not be manipulated nor the piece fired.

This apparatus therefore effectually prevents accidents which are due to the incomplete closure of the breech mechanism, and thus establishes its right to be called a safety device.

Again, the action of the lever upon the serrated wire is obviously exerted in the direction of the latter, which is a decided advantage over those primers in which there is a change of direction in the indented wire when pulled out by the lanyard.

This system can be applied to all pieces in which the interrupted screw system is used.

Principal dimensions, weights, etc.

	Metric.	English.
Diameter of bore	155 millimeters	6.10 inches.
Diameter of bore to bottom of grooves	157 millimeters	6.19 inches.
Total length of piece (35 calibers)	5,360 millimeters	211.02 inches.
Number of grooves	48	48.
Weight—		
Of piece, total	4,750 kilograms	10,472 pounds.
Of projectile	50 kilograms	110.23 pounds.
Of powder charge	25 kilograms	55.11 pounds.
Initial velocity	650 meters	2,132.5 feet.

(B) THE 155-MILLIMETER NAVAL CARRIAGE.

(Plates XLVI and XLVI a.)

This is a cast-steel carriage with a center pivot and hydraulic brake. A special apparatus insures the return in battery and holds it in this position firmly enough to secure it during the rolling of the vessel. A shield of chrome-steel plate attached to the chassis protects the gunners from the fire of revolving cannon and musketry.

Details of the De Bange carriage.—The chief characteristics of this carriage are:

(1) The arrangement of the hydraulic brakes at the height of the trunnions, in order that the resistance of the brake may be directly opposed to the effort of the gun upon the carriage.

(2) The special pointing apparatus fitted with automatic arrangements for throwing in gear and out of gear, which allows the elevation to be varied at the last moment.

The carriage comprises four principal parts, viz:

(1) A circular base or saddle, R, fastened to the deck of the vessel.

(2) A rotating chassis, B, resting on the base or stand through the interposition of conical friction rollers, G.

(3) The top carriage or cradle which supports the hydraulic brake cylinders.

(4) The pointing apparatus.

The base or stand has at its center the pivot P. It is furnished with a conical track, A, upon which the friction rollers G move, and with a circular toothed rack, *h*, by which the system is traversed. It has also a projecting rim, to the under side of which are adjusted the claws bolted to the chassis and intended to secure the chassis in position upon the stand.

The chassis B carries a part of the pointing gear, the sliding rails M, upon which the carriage rests and which are inclined to the front; the piston rods *t* and the pistons *c* of the hydraulic brake.

The top carriage or cradle carries the brake cylinders, the trunnion boxes T, and the cap squares S. It rests upon the sliding rails M by the interposition of guide plates N, which have exterior flanges to secure its position upon the rails. The second part of the pointing system is also fastened to the top carriage. The axis of the hydraulic cylinders and of the trunnions are in the same plane, in order that the recoil may act directly upon the brakes, and therefore avoid the formation of a couple at the instant of firing.

The pointing system is divided into two parts, one fixed to the chassis and the other to the top carriage. The first comprises a handwheel V, which, by the intervention of the beveled gear-wheels J and D gives a movement of rotation to the arbor F, terminated by a clutch, E. The second part attached to the top carriage comprises a clutch E′, carried by the arbor F, which penetrates the interior of a cylindrical case Q, then diminishes rapidly in diameter, forming a shoulder which presses against a spiral spring *r*; inside the case Q the arbor F′ passes through a screw H which is fastened to it in the following manner: The screw has two longitudinal grooves, *g* and *d*, corresponding to two grooves *e* and *f* in the arbor; these are brought opposite each other and held by keys which engage both with a gentle friction and are maintained longitudinally upon the screw by two disks *a* and *b*.

The screw (or worm-gear) H gives motion to the pinion L, which is attached to the same arbor as the pinion K, that engages with a toothed arbor fastened to the piece itself.

At each end, inside the gear case Q, are some Belleville disk springs, I, through which the arbor passes. These springs press against the ends of the case and the ends of the worm-gear.

Action of the pointing apparatus.—When the clutches E and E′ are in contact, every movement of the handwheel V is transmitted to the piece and the necessary elevation is easily given.

At the instant of explosion the recoil, carrying back the top carriage or cradle, disengages the clutch E′ from the clutch E, and the system is thrown out of gear. On the other hand, the oscillations of the

piece will be transmitted to the pinion L, which will tend to displace the worm in the direction of the shaft and will compress the spring I. When the piece returns in battery the clutches E and E′ again come in contact, but it is possible that owing to a slight displacement they may not reëngage; then the shaft F′ will be crowded to the rear, and will slide in the gear case Q and through the worm H, thanks to the prolongation of the key-grooves *e* and *f*. During this backward motion the shaft will compress the spiral spring *v*, which will cause the clutches to reëngage as soon as the claws are suitably disposed by a slight movement of the handwheel V.

Principal dimensions, weight, etc.

	Metric.	English.
Weight of axis and trunnions above deck	1,100 millimeters	43.31 inches.
Maximum recoil	650 millimeters	25.59 inches.
Limiting angles of fire:		
Elevation	+25 degrees	+25 degrees.
Depression	—10 degrees	—10 degrees.
Weight of carriage with chassis and cradle	6,000 kilograms	13,227.7 pounds.
Weight of shield	670 kilograms	1,477.1 pounds.

(C) 155-MILLIMETERS (6.1-INCH) PROJECTILES.

The only ones shown of this caliber were the common shell and special proof projectile for the gun 35 calibers long.

Weights.

(1) COMMON SHELL.

This is made of cast iron and is furnished with a percussion fuse.

	Metric.	English.
Weight—		
of shell, empty	33.25 kilograms	73.3 pounds.
of bursting charge	1.48 kilograms	3.26 pounds.
of fuse	0.22 kilograms	.55 pounds.
Total weight	34.95 kilograms	77.11 pounds.

(2) EXPERIMENTAL PROJECTILE, 35-CALIBER GUN.

This proof projectile is cylindrical and made of cast iron. Total weight, 50 kilograms (110.23 pounds).

(D) THE 270-MILLIMETER (10.63-INCH) MORTAR AND CARRIAGE.

(Plate XLVII.)

The 270-millimeter mortar is similar to that adopted by France for seacoast service. The only difference in the French service carriage is the position of the friction rollers for running in battery. It is a sliding carriage and receives wheels only for transportation.

Principal dimensions, weight, etc.

	Metric.	English.
Diameter of bore	270 millimeters	10.63 inches.
Diameter of bore to bottom of grooves	273.4 millimeters	10.76 inches.
Total length of piece (12.5 calibers)	3,400 millimeters.	133.86 inches.
Number of grooves	80	80.
Total weight of piece	6,000 kilograms	13,227.7 pounds.
Weight—		
of projectile	170 kilograms	374.8 pounds.
of powder charge	15 kilograms	33.07 pounds.
Initial velocity	300 meters	984.26 feet.
Height of axis of trunnions (in battery)	1,660 millimeters	65.35 inches.
Length of base of support	2,500 millimeters	98.42 inches.
Weight of carriage	6,000 kilograms	13,227.7 pounds.

(E) 230-MILLIMETER (12.6-INCH) GUN AND CARRIAGE.

This is a high-power gun mounted on a seacoast carriage, but could be used on board war vessels by placing it upon a different carriage.

This gun, very light for its high power, is reënforced with the biconical hooping or frettage of Col. de Bange.

The object of this system of frettage is to make the frettes assist in increasing the longitudinal resistance of the gun.

The firing is done the same as in the 155-millimeter gun.

The carriage, entirely of steel, is so contrived as to give extended angles of fire and to render traversing very easy; the whole weight of the compound system or mounting being borne by the pivot stand or bolster; it is only at the instant of recoil that the rear of the chassis bears upon the traversing circles.

The hydraulic brakes are opposed at the same time to the recoil and to the raising of the carriage.

Principal dimensions, weights, etc.

	Metric.	English.
Diameter of bore	320 millimeters	12.6 inches.
Diameter of bore to bottom of grooves	323 millimeters	12.72 inches.
Total length of piece (39 calibers)	12,460 millimeters	510.51 inches.
Number of grooves	120	120.
Weight—		
of piece, total	47 tonnes	46.3 tons.
of projectile	400 kilograms	831.85 pounds.
of powder charge	200 kilograms	440.92 pounds.
Initial velocity	650 meters	2,132.5 feet.
Maximum range	20 kilometers	12.4 miles.
Height of axis of trunnions above ground	3,500 millimeters	137.8 inches.
Maximum recoil	2,000 millimeters	78.74 inches.
Limiting angles of fire:		
Elevation	+30°	+30°.
Depression	−12°	−12°.
Weight of carriage with chassis and pivot bolster	54 tonnes	53.1 tons.

From trials made at Calais the 7th, 8th, and 9th of May, 1889, by the experimental commission, the energy of the projectile at the muzzle was 8,622 tonnes meters—27,840 feet-tons.

This energy would be sufficient to raise the gun to a height of 183 meters (600.4 feet) and to produce the following effects:

Thickness of wrough-tiron plate perforated by the projectile.

	Metric.	English.
At the muzzle	90 centimeters	35.43 inches.
At 1,500 meters (1,640 yards)	75 centimeters	29.52 inches.

Thickness of best steel plate perforated by the projectile.

	Metric.	English.
At the muzzle	60 centimeters	23.6 inches.
At 1,500 meters (1,640 yards)	50 centimeters	19.68 inches.

The above data regarding the energy of the projectile are given by the company.

(F) THE 320-MILLIMETER (12.6-INCH) PROJECTILE.

The only projectile of this caliber exhibited was an ogival trial projectile, weighing 400 kilograms (or 881.85 pounds).

THE ENGSTRÖM 57-MILLIMETER (2.24-INCH) RAPID-FIRING GUN.

(Plates XLVIII, XLVIII a, XLIX, and XLIX a.)

This system was invented by M. Engström, capitaine de vaisseau of the Swedish navy. Two guns of the same caliber (57 millimeters) were exhibited; one light, the other heavy. The former is designed for the flank defense of ditches and for field service; the latter or heavier piece is a high-power gun, and is intended for service against torpedo boats. The carriage for the light gun is an elastic carriage in which the slight energy of recoil is absorbed by a number of Bellville disk springs. It has no pointing apparatus, as the gun is furnished with a shoulder piece or cross and is directed and fired from the shoulder.

The carriage for the heavy gun has an hydraulic brake and a center pivot. The recoil of this piece is also very slight. The gun is pointed by means of a cross fastened to the carriage.

DESCRIPTION OF BREECH MECHANISM.

The breech mechanism is attached to the gun by four lugs or ears situated on the base ring of the gun, and forming part of it.

The principal parts are: (1) The movable breech, with its bolt and wheel; (2) the locking device, with its bolt and wheel; (3) the lock, composed of the detonating hammer, the mainspring, and the trigger; (4) the two extractors; (5) the spring catch; (6) the automaton.

As in all rapid-firing guns, the gas obturation is effected by the metallic cartridge case.

The movable breech.—The movable breech is pressed against the face of the breech of the piece when the latter is closed.

The lower part of the movable breech is traversed in a direction perpendicular to the axis of the gun by a bolt which passes through the two lower ears of the gun. The breech rotates with the bolt, to which it is connected by a fixed heel or spur which engages in a groove cut in the breech.

A wheel with two sets of cogs is keyed upon the right-hand extremity of the bolt, so that the bolt and wheel may be considered as one piece.

This arrangement insures the breech following the movement of the wheel.

The bolt can be introduced through the holes in the breech and the lower ears, or withdrawn from them, only when the breech is in its lowest position or open, as it is only in this position that the grooves in the breech and right lower ear correspond longitudinally.

This bolt is retained in position when the breech is open by the wheel of the locking device, which then bears against the breech wheel. In any other position of the breech the bolt is retained in its lodgment by the right end of the fixed key or spur.

The locking device.—The movable breech, being closed against the face of the breech, is retained in this vertical position by the locking catch. The latter, being pressed down over the rear face of the movable breech, clasps it at its strongest part.

The locking catch is assembled to the two upper ears on the breech in a similar manner to the attachment of the movable breech to the two lower ears, *i. e.*, by a bolt key.

The bolt can be removed in any position of the catch by pulling out the key P.

The locking catch, which is manipulated by a lever, one end of which forms a handle, is rigidly fastened at the right to a wheel carrying two arms terminated by some cogs or teeth designed to engage the lower wheel of the movable breech.

The left face of this wheel on the catch is in a vertical plane slightly outside of the right face of the breech wheel, so that when the breech is opened the wheel on the catch slides upon the right face of the lower wheel and retains it. The breech-assembling bolt can not then be withdrawn.

In order to withdraw this bolt it is necessary, in the first place, that the breech be open, for it is only in this position that the key

grooves in the breech and lower ear correspond; and in the second place that the key of the assembling bolt of the catch be withdrawn, which permits the removal of this bolt and its wheel toward the right. This done, the assembling bolt of the breech can be pulled out, also toward the right.

The lock.—The detonating lock acts in a cavity of the movable breech in the direction of the axis of the gun. It is provided with three notches or stops *e e e*. To introduce or remove it, the notches must pass through a hole in the rear of the breech. This hole has the same form as the section of the hammer, transverse to the three notches; that is, it is cut out in three segments of 60 degrees each.

When the notches have passed through this hole, the hammer is turned 60 degrees to the left and then these notches may rest against the shoulders of the hole. There are also on the hammer three lugs which slide in the hole in the breech, so that the hammer can not be turned or taken out until pulled to the rear sufficiently for the notches to rest on the above-mentioned shoulders.

The hammer is firmly held in a bridle *d*, whose right arm serves to hold back the hammer when the lock is cocked, and whose left arm serves partly for cocking and partly as a support for the mainspring. The firing pin can easily be replaced.

The mainspring.—This spring, *k*, is supported by two small trunnions, *ii*, placed in cavities in the lugs on the breech. The spring is removed by raising it sufficiently to disengage the trunnions from their cavities. The upper end of the spring has a circular loop fashioned so as to admit a finger to remove the spring without the aid of a tool. This is especially easy after taking out the hammer. The small trunnions of the spring are kept in position by a branch of the spring in the form of a fork with two arms. These two arms pass under the movable breech and are terminated at the extractors.

The upper branch of the mainspring can pass to the left of the hammer, in which case the latter can be removed by turning it 60 degrees to the right.

The lock-slide.—The lock-slide H joins the locking catch with the hammer and is placed in a cavity on the left side of the movable breech, so that this slide can not be dismounted until it is drawn back and the hammer has been removed.

The slide has two arms, the one, *h*, to act against the hammer bridle, and the other for cocking. The latter moves in a cavity in the locking-catch; when the catch is raised, its lug *s* presses against the arm *f* and pushes back the slide and hammer. When the catch is pressed down the slide returns to its place.

The trigger.—The detent or trigger rotates about a pivot *o* fastened to the right side of the movable breech. The right arm *d* of the hammer bridle sustains the sear *k*, which is situated upon the

left side of the arm *o* of the trigger and prevents the firing-pin from falling before the hammer bridle is sufficiently withdrawn toward the rear.

Besides the branch *o*, the trigger has two other arms, the sear arm *l* and the safety-arm *m*. The arm *l* moves in a cavity on the right side of the locking-catch and serves to disengage the sear *k* when it is drawn back by the lug *r* of the catch. The object of the arm *m* with its lug *n* is to retain the trigger in the cocked position when the breech commences to move to the rear.

When the sear is disengaged the lug *n* is raised out of its hole and can slide upon the circular surface of the right-hand lower ear.

The extractors.—These extractors M M can be moved upon the trunnions *b b* fixed in the breech. This rotation is limited to about a quarter turn, so that when the mechanism is closed they may take a position parallel to the breech and against the rear face of the piece, and when the breech is open they are nearly vertical and against the front face of the breech. The mainspring has its arm under the breech in the form of a fork with two arms, each one going to its corresponding extractor and pressing it so that the upper end of the extractor can enter between the head of the shell and the rear face of the gun. Hence, when the breech begins to move to the rear the extractors commence also to draw the shell to the rear with a strong leverage, and when the latter is extracted it is thrown to the rear.

The spring catch.—This catch G is provided with a spring N, which tends to elevate its longer arm, so that when the mechanism is closed the other arm of the catch can engage under the locking lug *w*, situated on the right hand upper ear of the gun. The essential advantages claimed for this catch is that it aids in elevating and depressing the piece, and that it is not added as a safety device.

The automaton.—This bolt O passes through the spring catch G, and thence into a hole in the lever of the locking catch. Turned with its arm supported against the spring catch, this arm comes in contact with the sear-arm *e* an instant before the mechanism is closed, and then sets free the detent when the mechanism is completely closed. The spring N of the spring catch has its support against a plane surface of the automaton, and as the part of the latter which rests in the lever of the locking catch is round, the automaton can not be removed in this position, because it is held by the spring N.

The automaton is constructed to retain the spring catch so that it can not engage under the lug on the right-hand upper ear. In this position of the automaton the firing can be done with the greatest rapidity, for then it is only necessary to raise or lower the handle of the locking device.

When it is desired to change the above-mentioned fire to that in which the trigger *o* is pulled by the finger, it is only necessary to give

the automaton a half turn. Then the spring catch is freed and the spring N presses its short arm under the locking lug u of the ear; and as neither the arm of the automaton nor any part of the locking device touches the sear arm, there is no automatic disengagement. As the part of the automaton upon which the spring bears in this position is a plane surface, the automaton will be retained in place by the spring. In order that the spring catch may remain free in this position of the automaton, the latter is excentric, so that the flange of the catch can enter the automaton soon enough to permit the free movement of the little arm of the catch and its entrance in the locking stud without interference.

ACTION OF MECHANISM.

Supposing the breech closed and the gun fired, the action is as follows:

Seize the handle of the lever of the locking device with the right hand and press with the thumb the locking device so that the locking stud under the ear on the gun will disengage out. Raise the lever and the lock is cocked by means of the arm S of the locking device, which presses back the arm f of the slide H, and then the hammer by its bridle a. Continuing the upward movement of the lever, the stud r of the locking device carries back the sear arm l so that the sear K is pressed down and engages the hammer by means of the bridle. The lock is cocked. Still continuing the upward movement, the locking device starts the movable breech A; the central studs t t press the breech to the rear until the wheels E and F engage the first tooth, and then the locking device frees at the same time the end of the movable breech and opens it.

The movable breech rests in a position about 45 to 48 degrees below the horizontal. The downward motion is arrested by the two studs a a, which strike against an elastic cushion fastened to the under side of the gun.

As the two arms of the mainspring are pressing against the extractors so that their points slide on the rear face of the piece, the two points of the extractors pass between the flange of the shell and the face of the piece and start it toward the rear. When the breech is sufficiently opened for the extractors to be at nearly a right angle with the movable breech, they follow its movements and throw the shell to the rear. It is seen that after the slide has moved sufficiently to the rear to cock the lock, the slide is retained in this position by a cylindrical surface on the locking device while the breech rests against the rear face of the piece, and that another cylindrical surface to the right of the breech holds the sear arm back and the sear in its support against the bridle until the breech commences its backward movement. The sear remains in this position while the breech is withdrawn from the rear face by means of the stud of the

detent which slides over the cylindrical surface of the right-hand lower ear.

In closing, the motion is reversed, and when the movable breech approaches the face of the piece the engagement between the toothed wheels ceases and the breech strikes the central studs of the locking device, so that this blow accelerates the clamping of the mechanism and forces the cartridge home strongly.

The cylindrical surfaces of the locking device prevent the slide H and the detent *l* from being moved when the breech strikes the rear face of the gun, and it is only when the locking catch has commenced to clasp the movable breech, and when the cavities in the catch for the arms of the slide and sear have arrived against these arms, that they are released and leave the hammer cocked. The piece can not be fired until the slide is pushed in place by the locking device, and that only occurs when the lever is pressed down; that is, when the mechanism is closed.

It is easily seen that this is a very complicated construction, and will require very accurate fitting and adjusting.

Principal dimensions, weights, etc.

LIGHT.

	Metric.	English.
Diameter of bore	57 millimeters	2.24 inches.
Diameter of bore to bottom of grooves	57.6 millimeters	2.267 inches.
Total length of piece	1,495 millimeters	58.86 inches.
Total length in calibers	26	26.
Number of grooves	24	24.
Weight—		
of piece, total	200 kilograms	440.9 pounds.
of projectile	2.75 kilograms	6.06 pounds.
of powder charge	0.60 kilogram	1.32 pounds.
Initial velocity	475 meters	1,558.4 feet.
Rapidity of fire per minute	30 to 40	30 to 40.
Height of axis of trunnions above ground	1,125 millimeters	44.29 inches.
Maximum recoil	80 millimeters	3.15 inches.
Limiting angles of fire:		
Elevation	+10 degrees	+10 degrees.
Depression	−20 degrees	−20 degrees.
Weight of carriage	550 kilograms	1,212.5 pounds.

HEAVY.

Diameter of bore	57 millimeters	2.24 inches.
Diameter of bore to bottom of grooves	57.6 millimeters	2.267 inches.
Total length of piece	2,275 millimeters	89.56 inches.
Total length in calibers	40	40.
Number of grooves	24	24.
Weight—		
of piece, total	300 kilograms	661.4 pounds.
of projectile	2.75 kilograms	6.06 pounds.
of powder charge	0.90 kilogram	1.98 pounds.

Principal dimensions, weights, etc.—Continued.

	Metric.	English.
Initial velocity	557 meters	1,827.5 feet.
Rapidity of fire per minute	30 to 35	30 to 35.
Height of axis of trunnions above ground		
Maximum recoil	150 millimeters	59.05 inches.
Limiting angles of fire:		
Elevation	+13 degrees	+13 degrees.
Depression	−20 degrees	−20 degrees.
Weight of carriage	575 kilograms	1,267.6 pounds.

PROJECTILES FOR 157-MILLIMETER (2.24-INCH) RAPID-FIRING GUNS (ENGSTRÖM.)

These projectiles are designed to fire from the 57-millimeter Engström rapid-firing guns. The light gun employs the common shell and the case shot, the heavy gun the common shell and the perforating shell. The cartridge is formed of a case or shell, either of brass or of sailcloth and paper, with a brass base or head, which contains the powder charge. The base of the projectile is inserted in the front end of the case.

Principal weights, etc.

CARTRIDGE CASE.

	Metric.	English.
Brass case for light guns	0.95 kilogram	1.98 pounds.
Brass case for heavy guns	1.15 kilograms	2.53 pounds.
Case of sail cloth and paper:		
For light guns	0.80 kilogram	1.76 pounds.
For heavy guns	0.90 kilogram	1.98 pounds.

COMMON SHELL.

The common shell is made of cast iron and is furnished with a percussion fuse.

	Metric.	English.
Weight—		
of empty shell	2.57 kilograms	5.66 pounds.
of bursting charge	0.10 kilogram	0.22 pound.
of fuse	0.08 kilogram	0.18 pound.
Total weight	2.75 kilograms	6.06 pounds.

CASE SHOT.

This is also of cast iron with a percussion fuse.

	Metric.	English.
Number of balls	104	104.
Weight—		
of shell empty	2.64 kilograms	5.82 pounds.
of bursting charge	0.08 kilogram	0.18 pound.
of fuse	0.08 kilogram	0.18 pound.
Total weight	2.80 kilograms	6.18 pounds.

PERFORATING SHELL.

This shell is made of chilled cast iron and has a base fuse.

	Metric.	English.
Weight—		
of shell empty	2.65 kilograms	5.84 pounds.
of bursting charge	0.05 kilogram	0.11 pound.
of fuse	0.05 kilogram	0.11 pound.
Total weight	2.75 kilograms	6.06 pounds.

PART II.—FRENCH LIFE-SAVING APPARATUS.

[Exhibited in class 65.]

The French life-saving service is not a Government organization, but relies upon private subscriptions for the funds to furnish and keep up the stations. Its official designation is the "Société Centrale de Sauvetage des Naufragés."

This society has fifty life boat stations, seventy-one first-class life-saving stations, furnished with line-throwing guns, projectiles, hawsers, whip line, and breeches-buoy apparatus; two hundred and four second-class stations, with line-throwing small arm for short distances, and the necessary apparatus; seventy-four third-class stations, with life belts and accessories; and a relief station is established at Gatzeau on the island of Oleron.

Besides these, the light-house authorities have established stations, furnished with the small arm used for throwing lines, in forty-seven light-houses, and the "Compagnie des Messageries Maritimes" and the "Compagnie Générale Transatlantique" have placed upon their steamers seventy-eight rampart guns for throwing lines.

CHAPTER I.

DESCRIPTION OF APPARATUS FOR FIRST-CLASS STATIONS.

(1) LINE-THROWING GUNS.

(Plate L.)

The gun used is called "le perrier." It is a small bronze 1-pounder gun formerly employed by the navy, but is now obsolete and discarded from the service. It has been transferred to the life-saving service for use at its stations, and has been adopted by that service from motives of economy. The weight is about 85 kilograms (187.4 pounds). The diameter of the bore is 53 millimeters (2.08 inches). The vent-piece is made of steel, and is placed near the front end of the powder charge, with a view to "diminishing the fatigue of the piece." The vent has a diameter of 5.6 millimeters (0.22 inch), and is inclined toward the front at an angle of 25 degrees, so that when the piece is fired at that angle the primer may not be pulled out by the lanyard.

A line-carrying projectile is fired from this piece, and serves to establish communication from the shore to the vessel or from the vessel to the shore.

(2) THE CARRIAGE.

(Plate LI.)

This serves to transport the gun from place to place and to support it in firing. The wheels, raising the gun above the soil, permit a nearer approach to the vessel to be relieved, since it can be run down a beach until the wheels are in the water without danger of wetting the charge.

The carriage consists of two flasks made of sheet metal joined by transoms and mounted upon an axle bearing the two wheels. A wooden lever is inserted at the end of the trail, by which two or four men can haul the carriage. This lever can be easily dismounted. Two maneuvering handles, one on each side, are fixed near the end of the trail. An elevating quoin fastened between the flasks serves to give the desired elevation in pointing.

(3) PROJECTILES.

(Plate L.)

The projectile is made of wrought iron, cylindro-ogival in form. The rear end is flattened, and pierced with a hole to form the point of attachment for a tail piece made of twisted galvanized iron wire, to the rear of which is attached the shot line. This tail piece is supposed to favor the line by giving a certain amount of elasticity in the first part of the trajectory, and removes the shot line far enough from the mouth of the piece to preserve it from any danger of being burned off. The head of the projectile is ogival.

	Metric.	English.
Length of projectile	617 millimeters	24.3 inches.
Diameter of projectile	52 millimeters	2.05 inches.
Weight, including tail piece	8.5 kilograms	18.74 pounds.

(4) SHOT LINES.

These are the lines carried out by the projectiles to form the first line of communication between the vessels and the shore, or between vessels. These lines are twisted, and made of the first quality of French or Italian hemp. Two sizes are employed.

Lines.	Diameter.		Length.	
	Metric.	English.	Metric.	English.
	Mm.	*In.*	*Meters.*	*Yards.*
Small	5	0.197	450	492
Large	7	0.276	350	383

The choice of lines for adoption in the service was based upon tests made with the Chévefy dynamometer, March 27, 1886, which gave the following results :

[Material first quality French hemp, twisted.]

Diameter.		Mean breaking weight.		Weight per meter.
Metric.	English.	Metric.	English.	
Mm.	*Inches.*	*Kilos.*	*Pounds.*	*Grams.*
5	0.197	307	676.8	22
6	0.236	358	788.2	33
7	0.276	502	1,106.7	42
8	0.315	530	1,168.4	51
9	0.354	730	1,609.4	65

These lines are stowed in faking boxes. In some cases the 5-millimeter lines are simply laid up in balls, which are lighter and more easily transported than the boxes. The balls contain 200 to 220 meters (218 to 240 yards) of line, and may be united by means of a double knot.

(5) FAKING BOXES.

(Plate LII.)

There are two sizes of faking boxes, one to carry the 350 meters of 7-millimeter line and the other the 450 meters of 5-millimeter line.

Each box is composed of three parts—

(1) A wooden frame into whose four sides are screwed the conical faking pins to hold the line.

(2) A false bottom of wood 20-millimeters (0.787 inch) thick, pierced with ellipsoidal holes corresponding to the faking pins. It is placed over the pins before faking the lines, and serves two purposes: First, to close the bottom of the box and protect the line from moisture, and, second, to hold the fakes in position during the withdrawal of the pins when preparing for firing.

(3) A rectangular wooden box, open on one face, which is placed over the pins after the line is laid up. This is fastened to the projecting edges of the frame by means of a hinged copper latch and a staple in whose eye-holes is hooked a carbine-hook by way of a retaining key.

The boxes are always transported with the frame down until just before firing when they are turned bottom up, the latches loosened, and the frame and pins withdrawn by pressing down at the same time upon the false bottom which is removed after inclining the box slightly to the front.

(6) THE SPONGE AND LADLE.

(Plate LIII.)

This combination implement is used to clean the bore and to withdraw a cartridge or any part of a cartridge bag or other object not completely consumed in firing. The body or staff is made of wood. One end is cylindrical and covered with sheepskin with the wool on to form a sponge; the other extremity carries a copper ladle. A groove on the body painted white shows the position of the ladle in the bore. Total length, 1.220 meters (4 feet); diameter of sponge tenon, 52 millimeters (2.05 inches).

(7) POWDER MEASURES.

(Plate LIII.)

These are two copper cylinders sliding friction tight one in the other like a telescope tube. The outer cylinder has a groove with

numbered slots on one side into which a stop screw on the inner cylinder can be rotated. This arrangement furnishes a graduated measure which gives charges of powder varying from 180 to 270 grammes in weight (6.35 to 9.52 ounces).

(8) MUNITION POUCH.

(Plate LIII.)

This is a leather pouch with a flap closing down by means of a billet and button. It is designed to carry the friction primers, the lanyard, priming wires, vent punch, and quadrant for elevating. The pouch is attached to a belt armed with a hook, and is worn about the waist by the chief of piece during the time of drill or of action at a wreck.

Priming wires.—These are made of steel wire. One end of each is pointed and the other furnished with a loop or eye-hole to which a line is attached. The other extremity of this line is fastened to one of the loops of the pouch. Length of priming wire, 150 millimeters (5.90 inches). Diameter of priming wire, 3.5 millimeters (0.14 inches). Length of line, 600 millimeters (23.62 inches).

Lanyard.—The lanyard is a strong cord terminated at one end by a small iron hook sharply curved which is inserted in the loop of the friction primer in firing. The other end has a leather loop through which the chief of the piece passes his hand.

Quadrant.—This is made of wood and is painted black, with the divisions in white. A flat part slightly rounded on the edges to fit the bore of the gun is designed to be inserted in the bore, leaving the graduated arc projecting. A plumb line is suspended from the center of the arc. This implement in connection with the quoin above described serves to give the required elevation in pointing.

(9) AMMUNITION, ETC.

Powder.—The powder adopted as most suitable for the service is that used by the French artillery, and known as Cannon powder "C_1." The maximum charges are as follows: For 7 millimeters (0.275-inch) line, 270 grammes (9.52 ounces); for 5 millimeters (0.197-inch) line, 200 grammes (7.05 ounces). These charges are measured by the graduated device above explained.

Cartridge bags.—These are made of asbestos cloth. They are prepared and sent from Paris in packages of twenty-five and of fifty, upon requisitions made on the society. They are of two sizes, according to the charges to be employed. If the firing is unsuccessful on account of breaking the lines, the charge is diminished by taking out 10 to 20 grammes of powder, estimating the amount removed.

With the maximum charges given above there should be obtained a range of about 250 meters (273.4 yards) with a 7-millimeter (0.276-

inch) line, and a range of about 350 meters (383 yards) with the 5-millimeters (0.197-inch) line.

Wads.—The wads used are cork disks whose diameters equal the caliber of the gun 53 millimeters (2.08 inches), and from 5 to 6 centimeters (1.97 to 2.36 inches) thick. These are designed to act as gas checks or obturators for the powder gases and to diminish slightly the first shock received by the projectile.

Friction primers.—These are the ordinary friction primers employed by the land artillery.

Cartridge box.—This is a box made of tin plate to hold a number of cartridges made up in advance and held in reserve ready for service. The weight of each charge is marked on the cartridge bag.

Powder can.—This is a zinc can closed with a copper cap screwed on. The supply of powder is kept in this can where it is protected from the atmosphere.

(10) POLES.

Two long poles are set up at a proper distance apart to serve as a target in practice firing. These may be bought or improvised at the station. In practice, the line must fall between these poles no matter where the projectile falls.

(11) DECAMETER.

This is a surveyor's measure 10 meters (32.8 feet, long, for measuring the distance between the target poles, and the ranges and deviations of the projectiles.

The powder and friction primers are obtained from the nearest artillery depot; the cartridge bags from the central society.

(12) THE DOUBLE WHIP.

(Plate LIV.)

This line is a three-strand manila rope, 16 millimeters (0.63 inch) in diameter, and having a length double that of the hawser. It runs freely in a swivel pulley provided with a whip at least 4 meters (13 feet) in length. As soon as the first communication has been established, the crew of the stranded vessel should haul out this pulley with the double whip and fasten it on board, as is indicated upon the tally board No. 1.

(13) HAWSER.

(Plate LIV.)

Made of manila hemp, 28 millimeters (1.1 inches) in diameter, and of a length varying according to locality. It serves to sustain and guide the breeches buoy. The ends must be terminated in points or rat-

tails, and a rope's end passed and fixed between the strands at 3 meters (9.84 feet) from the end allows it to be fastened to one of the lines of the double whip.

The hawser is sent on board by means of the double whip and fastened to the vessel as directed on tally board No. 2.

(14) DIRECTING PULLEYS.

(Plate LV.)

The one shown (No. 1 in plate) has two bronze sheaves placed side by side and small copper rollers on the sides. It runs from one end of the hawser to the other, supporting the breeches buoy, which is fastened to it by means of a strap and wooden belaying pin. When the hawser is not employed, this pulley is replaced by a small snatch block which runs on one of the arms of the double whip, the other arm being fastened to the two thimbles attached to the breeches buoy.

(15) BREECHES BUOY.

(Plate LV.)

A circular buoy, made of cork, to which is adapted a pair of short breeches, made of canvas and very large. It is attached to the directing pulley or to the double whip, according to circumstances, and serves to receive one by one the shipwrecked and convey them to the shore.

(16) TACKLE.

(Plate LVI.)

Formed of a tackle made of tarred rope and two pulleys, one a double pulley with hook block to fasten to the point of attachment in the soil, and the other single or double, with double whip, for attaching to the hawser. It serves to stretch the latter when it has been sent off and made fast on board the stranded vessel.

(17) TRIPOD.

(Plate LVI.)

Made of wood or wood trimmed with iron. A snatch block is hooked to a manila loop placed at the summit, through which passes the hawser. The object of the tripod is to elevate the hawser, below which runs the breeches buoy and the person it carries, so as to prevent the latter in approaching the beach from being rolled by the sea over the pebbles on a flat coast, or from being stopped by the angle of a steep shore if it be bluffy.

In setting up the tripod care must be taken to put the two shears in front in a line perpendicular to the direction of the hawser, and the third in rear in the same plane with the hawser.

(18) SAND ANCHOR.

This serves to engage the double pulley of the tackle in order to stretch and hold the hawser.

According to locality this may be an anchor, an endless screw, a plank, in the middle of which is fixed a chain, or a pile shod with iron carrying a traverse. A set of shovels, pickaxes, and mallet is added to this material in order to facilitate the operation of preparing the site.

(19) TALLY BOARDS WITH INSCRIPTIONS.

No. 1 is 35 centimeters (13.78 inches) long, and is attached to the double whip; the other, marked No. 2, is 28 centimeters (11.2 inches) long, and is used on the hawser. They should always be fastened on the double whip and hawser, so as to be ready as soon as the apparatus is needed.

These tally boards bear the following instructions, written on the two sides in white upon black, red, or blue. On one side the inscription is in French, on the other side it is in English, Spanish, or Italian.

Tally board No. 1, belonging to the double whip, has the following inscription:

Fouettez la poulie le plus haut possible sur le bas mât ou à l'endroit le plus favorable si les bas mâts sont tombés. Détachez la ligne voyez que la corde coure facilement dans la poulie et faites signal au rivage.

Tally board No. 2, fastened to the hawser, has:

Amarrez cette aussière à deux pieds environ au dessus de la poulie, voyez que rien n'engage et que la corde coure facilement dans la poulie, puis faites signal au rivage.

(20) LANTERNS.

One lantern with red and white glasses for making night signals to the shipwrecked, one hand lantern to light the operations at night, and a candle box with candles to supply the lanterns.

(21) RED FLAG AND STAFF.

To make day signals to the stranded and to use as a danger signal to warn persons to keep away within a certain radius during drills.

(22) CANVAS BAG.

Containing several small objects, such as iron splicing fid or belaying pin, ball of tarred rope's ends, etc.

(23) HEAVING LEAD.

(Plate LVI.)

The heaving lead is a rattan stick, 46 centimeters (18.11 inches) long, fastened in a ball of lead weighing 700 grams (1.5 pounds), at one end, and furnished at the other end with a loop of braided leather thongs to receive the line. It is very useful in practice; the ease of throwing it, even in a tempest, to a distance of 25 to 30 meters (80 to 100 feet) makes it one of the most useful implements for life-saving purposes.

It can be thrown directly as would be a stone, but a greater range is obtained by throwing it like a sounding lead after having rotated it several times in succession.

For exercises on land a site will be chosen where the ground is not too hard in order not to bruise and wear off the lead in falling. Two pickets will be placed at 25 meters (82.02 feet) distance and 2 meters (6.56 feet) apart; and then the operator can take account of the range and accuracy of his casts.

It is important to practice frequently with the heaving lead; after becoming accustomed to it one easily obtains a range of 35 meters (115 feet).

(24) LIFE BELTS.

(Plate LVII.)

The life belts placed by the Société Centrale in all its stations are made of cork, Ward's system, large size.

The pieces of cork, sewed separately on a tan-colored canvas, form two tiers, between which passes a braided tape also sewed to the canvas, which permits the belt to be fastened around the loins. Other braided bands pass over the shoulders and support it in position upon the body.

These belts can sustain in the water 10 to 11 kilograms (22.05 to 24.25 pounds); they support, therefore, two men easily, the weight of a man in the water being only about 5 kilograms (11.02 pounds).

They are provided with a ring fixed in front to the tape of the belt and strongly fastened by a rope's end spliced immovably, which takes a turn around the body and is fastened by means of an eyelet and toggle.

If it be necessary to advance quite far into the water to rescue a person, a line is attached to the ring in the belt of which one end is held on shore by another person. The safety of the one who advances in the water is thus assured.

Mode of suspension.—The belts should always be suspended from three slightly curved brass hooks (Fig. 1 *bis*) in order that the tapes may be easily withdrawn.

In this position the cork is turned toward the wall and the canvas outside, which facilitates putting on and avoids the effects of humidity.

The hooks are placed triangularly, two of them below at 45 centimeters (17.71 inches) apart, the one above at equal distances from the other two and 70 millimeters (2.76 inches) above them. (Fig. 1, Plate LVII.)

Method of attachment.—The apparatus is held on the body by two suspenders and a waist belt. The suspenders, passed through a copper buckle and held by means of eyelets and tongues, are crossed on the back. (Figs. 3 and 4, Plate LVII.)

To give the suspenders a suitable length for the average man, it is necessary to stretch the waist belt out flat and to pass the tongue of the buckle in the hole corresponding, by stretching a little the suspenders. (Fig. 2, Plate LVII.)

Method of putting on the belt (Fig. 1, Plate LVII).—Seize the suspenders *a* and *b* with the right hand, *c* and *d* with the left hand; raise the belt so as to unhook it; pass the head at T and then the arms at VV; fasten the ends of the belt by passing the tape through the corresponding buckle, and, after having passed the line around the waist, engage the toggle in the eyelet.

When the belts have been wet in salt water they must be rinsed in fresh water before hanging them up in place, where they are in a better condition for drying rapidly. In cases where the attachments of the pieces of cork are broken, it is important to repair them immediately. One should frequently assure himself of the soundness of the tapes.

INSTRUCTIONS FOR FIRING.

(1) FAKING THE SHOT LINES.

(Plate LVIII.)

The faking of the lines is a very important operation, demanding a great deal of care. Everybody can learn to fake with a little practice and intelligence, but it is only by practicing that one becomes a skillful faker. One man alone can, in case of necessity, fake a line, but having to perform three operations at the same time he executes none of them well. Two men may be employed, but to be sure of success there must be three men. In order to facilitate the explanations we shall designate them by the numbers 1, 2, and 3. We point out below the functions of these three men, it being understood they execute them simultaneously.

No. 1 superintends the operation. He places before him, upon the empty faking box in order to have it more convenient, the frame carrying the faking pins and lowers the false bottom over them. He takes the end of the line passed to him by No. 3, and stretches it

the length of the box on the false bottom, then passes it outside of the pins *b*, *c*, *d*, *e*, etc., as is indicated in the figure in the plate. Arrived at the corner A, he again stretches the line along inside the faking pins until he reaches the corner B, and then passes it around *g*, *h*, *i*, *m*, etc., consecutively faking with the right hand and pressing down the loops on his side with the left hand.

No. 2 places himself opposite No. 1, on the other side of the frame, his duties consisting in indicating the pin to pass the line around and to press down the loops on his side upon the tiers previously placed.

No. 3 stands a meter or two from No. 1, and pays out the line to him. He removes all the turns. knots and kinks that may be formed.

In this way one can fake 450 meters (492 yards) in 30 minutes. As soon as this operation is completed, Nos. 1 and 2 take the faking box, turn it over the filled pins, close the hasps and hook the spring key in the staple.

Care must be taken not to fake the line too tightly as it draws the pins together towards the middle of the box and renders the removal of the false bottom difficult, if not impossible.

(2) FIRING.

As vessels nearly always run ashore by the wind blowing on shore the firing of line-carrying projectiles takes place either directly against the wind or with the wind at an angle from the front. There is rarely a case where the wind is perpendicular to the plane of fire, which is the most disadvantageous case.

The firing is generally done with an angle of elevation of 25 degrees, indicated by the quadrant. On acconnt of the action of the wind upon the projectile and the line, this angle appears to give the greatest range.

To fire against the wind.—In this fire the projectiles and lines suffer no lateral deviation, one must aim as closely as possible between the masts of the wrecked vessel.

The projectile passes over them and when it falls in the sea the line falls upon the deck and the crew seizes it. This fire is easier and should be employed, by preference, even when it is necessary to select a point on the shore more distant from the vessel in order to bring it in the plane of the wind.

In Fig. 1, Plate LIX, the vessel N is placed within the range of the projectile P. There is no danger of the projectile striking the wrecked persons; but if the vessel was at the extreme limit of the range the projectile would fall on the vessel and might strike the persons on board.

It is necessary then in order to avoid all chance of accident to place the gun so as to have the wind make a slight angle with the line of

fire if the configuration of the coast will permit it. This necessitates pointing slightly to the windward of the vessel, as will be shown directly.

To fire with a cross wind.—In this fire the projectile and the line it drags experience a more or less considerable deviation, according as the direction given to the projectile crosses the direction of the wind at a greater or less angle. But in any case the line is subjected to the action of the wind a great deal more than the projectile and settles down forming a curve resembling the profile of a pear. This phenomena (indicated in Plate LIX by Figs. 3 and 4) is explained by the fact that the part of the line near the projectile is held by it, while the other end is escaping freely from its faking box and that at the moment that the line has lost the velocity communicated by the projectile, the upper part settles down under the influence of the wind, which carries it off sideways.

There results from this that—

(1) For the same range of projectile the line falls on the lee side of the vessel at a distance so much the greater as the vessel is nearer the shore. The distance B B′, (Plate LIX, Fig. 4) is greater than A A′.

(2) In order to reach a vessel when the plane of the direction of the wind does not coincide with the plane of fire, it is necessary to direct the projectile to windward, taking into account the two elements; the deviation of the projectile P C P′ and the deviation of the line P′ C A′ for the most distant vessels, and P′ C B′ for the nearest vessel.

(3) In this firing, the projectile being directed so as to pass a certain distance to the windward of the vessel can never cause an accident.

(4) When the vessel is near the shore and when one can avoid firing with a cross wind, the deviation of the line may be diminished by firing under a smaller angle than 25 degrees. The line of the projectile P″ (Plate LIX, Figs. 3 and 4) fired under an angle of 20 degrees, for example, will reach the vessel B″, while that of the projectile P′, fired under an angle of 25 degrees, would pass to leeward.

(3) RULES FOR FIRING..

First rule. Establishment of the battery.—If the stranded vessel is within 200 or 300 meters (218.7 or 328 yards) according as the 7 millimeters (0.275 inch) or the 5 millimeters (0.197 inch) lines are used, one should as nearly as possible place the gun so as to fire directly against the wind, or at least to approach this condition as closely as possible.

If the stranded vessel is at a distance closely bordering on these limits, especially if it be at night, one should place the gun so as to take the wind a little quartering in order that in no case may the projectile fall upon the vessel.

Second rule. Pointing.—(1) In firing directly against the wind, one must aim directly over the vessel itself and between the two masts, under an angle of 25 degrees.

(2) When the position of the vessel, with respect to the shore, obliges one to fire across the wind, one should, depending on the force of the wind, aim more or less between its direction and that of the vessel. The first projectile fired will be observed with the closest attention in order to rectify the aim for the second shot.

(3) If the vessel is near enough to the shore so as not to require the maximum range, there is quite an advantage in diminishing the angle of fire so as to make the projectile pass not above but between the masts. One is certain then, whatever may be the direction of the wind, that the line will cling against the mast under the action of the wind and will be easily seized by the stranded crew. It is necessary to be sure in this case that there is no one in the rigging.

FIRING DRILL—TACTICS.

As the manipulation of the life-saving gun and apparatus is frequently required at night and under adverse circumstances of bad weather and more or less excitement, it is necessary that a crew be well drilled and disciplined in order that the material be transported and the firing executed with the greatest order possible, so that no time may be lost.

With this object in view a specific duty is assigned to each man of the crew, who is designated by a constant number.

It is assumed that the crew will consist of at least six men, who are numbered consecutively from 1 to 6. No. 1 acts as gunner or chief of piece.

(1) TRANSPORT OF MATERIAL.

After choosing a proper firing ground, Nos. 1 and 2 haul the gun to the practice ground by taking hold of the detachable lever; No. 3 carries the cartridge box; No. 4, the projectile; Nos. 5 and 6 prepare the faking box and line.

(2) IN BATTERY.

Arrived on the firing ground, Nos. 1 and 2 place the carriage in the most favorable position for firing, pointing the piece, approximately, and remove the movable hauling lever.

(3) AIM.

No. 1 introduces the quadrant in the mouth of the piece and signals to No. 2 to elevate or lower the breech by raising or lowering it by means of the cascable and quoin until the proper angle of fire is obtained (generally 25 degrees, the angle which gives the maximum range). No. 1 aids No. 2 by pressing down or raising the chase until the quoin is set to give the desired angle.

No. 3 prepares a cartridge of the weight given by the chief of piece.

Nos. 5 and 6 place the faking box upside down on the windward side of the piece, nearly opposite the muzzle and about a meter (3 feet) distant, unhook the clasps, remove the frame and pins by pressing gently at the same time upon the false bottom, and then remove the latter after inclining the box to the front at an angle of about 45 degrees to facilitate the paying out of the line.

No. 4 presents the projectile to No 5, who fastens the shot line in the eye, at the free end of the twisted wire shank, with two half-hitches. In this operation remove as little line from the box as possible, not more than 2 or 3 meters (6 to 10 feet) at most.

(4) LOAD.

No. 3 presents the cartridge to No. 1, who notes the weight, and then No. 3 inserts it in the piece, with a cork wad above it.

No. 4 introduces the projectile, point first, in the bore and presses the cartridge and wad to the bottom of the bore, but without jamming them down.

No. 1 pricks the cartridge with the priming wire, verifies the direction of the piece, inserts a primer in the vent, and hooks the lanyard in the loop of the primer.

(5) FIRE.

The crew fall back about 4 or 5 meters (13 to 16 feet) in rear and to one side. No. 1 moves back the length of the lanyard and a little to one side, in order to be clear of the carriage in its recoil, and then fires the piece by a steady, sharp pull from above downward.

If the line falls between the poles that represent the deck of a vessel, No. 5 and 6 go to the faking box and as soon as the line ceases running out, they seize the shot line and stand ready to pursue the subsequent operation.

If the shot fails to lay the line in the proper place the maneuver is repeated, after carefully sponging the piece.

(6) SPONGE.

No. 1 thrusts the priming wire in the vent to clear it, and then stops it by holding the thumb of his left hand on the vent during the sponging.

No. 2 takes the sponge, inserts it to the bottom of the bore and turns it several times in order to pick up with the ladle the remains of the cartridge, and then withdraws it without turning, with the white stripe of the shaft uppermost.

NOTE.—Care must be taken to thumb the vent properly in order that the air compressed by the sponge may extinguish any burning fragments of the cartridge bag which may be in the piece.

DRILLS.

If possible a firing ground should be chosen where the projectiles can fall on soft ground, to avoid injury. To prevent cutting the lines they should be picked up or rolled without dragging them on the ground.

The firing ground should be chosen so that if the lines break and the projectiles have a range of about 1,000 meters (1,090 yards) and a rather large deviation, especially if there is a cross wind, they can do no harm.

The wreck will be represented by two poles as high as possible, placed about 15 or 20 meters (50 to 65 feet) apart to represent the masts of a vessel.

The flight of the projectiles and the deviations of the lines must be observed and noted with care, as well as the force and direction of the wind. These indications and data are inserted in the proper blanks and transmitted to the life-saving service through the proper customs officers.

NOTE.—It must be distinctly understood that it is not the place where the projectile falls that is most important, but the place where the line falls at the target. It must fall between the poles or stakes, no matter where the projectile falls.

HANDLING OF THE BREECHES-BUOY APPARATUS—TACTICS.

As soon as a wreck is discovered the chief of the post warns his chiefs, if there be any present, and collects his crew as quickly as possible. He makes an attempt to have immediately the necessary horses. In order to avoid all loss of time, it is the duty of the officers as soon as they have a breeches-buoy apparatus in their division to assure themselves of the possibility of procuring horses in the vicinity under determinate conditions. While awaiting the arrival of horses the men start with the apparatus, pulling it with the men's harness, and direct their march toward the scene of disaster.

(1) HALT.

The apparatus wagon having arrived in rear of the firing point, the reels are taken off, the tongue or shafts removed and the front and rear gates dismounted, the faking boxes or the balls of line are placed on the ground with all the smaller material.

The double whip line is placed on the ground in two coils 15 to 20 meters (50 to 65 feet) apart, with the pulley with tail piece in the middle. The tripod is set up and the snatch block hooked in place in its ring. The anchor is established according to the means at hand.

(2) SEND OFF THE DOUBLE WHIP.

As soon as the shot line has been seized on board by the crew they must signal it to shore as follows: If it be during the day, one of the

crew separates from his companions and waves his hat, his hand, a handkerchief, a flag, etc.; if it be night, they fire a rocket, a gun, or more practically, they show a light above the rail and conceal it alternately, several times in succession.

Those on shore must have assured themselves that the first line of communication offers all the guarantees for standing the strain of hauling off the double whip and its pulley. If there be the least doubt, or if they have fired a projectile with the 5-millimeter line they will commence by attaching the 7-millimeter line to the first line of communication.

In any case, as soon as the signal indicated above is perceived from the shore, or by any other means it appears evident that the first line of communication is in the hands of the stranded crew, the life-saving crew bends the end of this line or that of the 7-millimeter line to the two branches of the double whip at 2 meters (6.56 feet) in rear of the pulley, then they bind the end of the tail piece or whip in front with a small selvage. They assure themselves that the tally board No. 1 is well fastened near the pulley as it always should be, and they make the following signal for the stranded crew to haul out the line.

One of the life-saving crew detaches himself from the group formed by the others; by day he waves a red flag, at night he shows and conceals alternately his red light from minute to minute.

The stranded crew haul out the line until they can secure the pulley and whip line with the tally board No. 1. They then make fast the tail of the whip upon a mast rather high up, or if the masts have fallen, to the best place they can find and watch that the lines do not foul. They cast off the original line of communication and signal to the shore to send out the hawser.

During this operation the chief of the shore party watches the running out of the whip and sees that there are no knots, kinks, or turns by putting on each branch some men as far apart as possible to pay out the line.

(3) SEND OFF THE HAWSER.

Immediately the signal on board is seen on the shore the hawser (to which is attached tally board No. 2) is sent off to the vessel by means of the whip line, one of whose branches has been bent on to it at 4 or 5 meters (13 to 16 feet) from the end, for which purpose the selvage passed between the strands was attached.

They haul upon the other branch of the whip in sending out the hawser, always keeping the branches clear of each other.

As soon as the stranded crew can seize the hawser they make it fast about 2 feet above the whip of the pulley of the whip line, then they detach the latter by loosening the gaskets and seeing the ends clear, after which they signal the shore as before.

During this operation, a man on shore has held the directing pulley through which the hawser must always be passed, and aided by one or two of his comrades he fixes to it the breeches buoy by attaching the latter to the strap of the pulley.

(4) STRETCH THE HAWSER.

As soon as the signal is seen on shore the hawser is passed through the snatch block on the tripod and hauled taut as much as possible by hand and then tightened up with the tackle.

(5) SEND OFF THE BREECHES BUOY.

The double whip is attached to the buoy by two half keys for rigging clasped upon the strap of the directing pulley.

A part of the men lay hold of the free branch of the double whip and haul the buoy out to the vessel, while the other life savers carry the other branch and follow its movements as necessity requires.

If possible the breeches buoy should be sent off on the same branch of the whip as the hawser, that is, if the hawser was sent out by the right hand branch of the whip, this is the branch that carries out the buoy also.

(6) HAUL BACK THE BREECHES BUOY.

As soon as the buoy is hauled out and a man placed in, a signal is made to the shore. At this signal the buoy and its load is hauled back by inverse means, that is, the men who paid out line before now haul in and the men who hauled out the line now pay out the line of their branch of the whip.

Repeat these operations until all are landed.

The two branches of the whip should always be kept as far apart as possible to prevent fouling.

Remark.—In some cases it may be necessary to haul the person saved through the waves. In this case it is well to employ Summer's method and attach a cord to the buoy and then to the whip line some distance from the buoy. This tends to maintain the person in the buoy in an upright position and does not plunge him so completely under water. (See Plate LX.)

(7) SPECIAL CASES.

There may be cases where circumstances force a departure from the foregoing rules. For example, if the stranded vessel is subjected to violent rolling motion, it is preferable not to stretch the hawser and retain it in a fixed manner. In this case let it be held by a sufficient number of men who move to and fro on the beach following the movements of the vessel.

In the case where there is evident danger of the vessel going to pieces soon, and there is not time to set up the hawser, then the breeches buoy must be used with the whip alone.

For this purpose bend the two ends of the whip to the eye holes on the buoy and suspend the latter from the little snatch block from the upper branch of the whip. If there be not time to get the ends of the whip to fasten to the buoy, fasten the whip at any point to the buoy, as shown in Fig. 1, Plate LXI.

(8) RETURN THE APPARATUS.

As soon as the crew is taken off, haul ashore the double whip. To save the other lines, wait until the weather moderates enough to go aboard the vessel and cast off or until it breaks up, when the hawser may be hauled ashore. The breeches buoy and whip line are replaced on the cart and returned to the station.

As soon as brought back all the cordage should be stretched out and dried, outside if the weather permits, if not, then inside the station. Some hooks are placed in the station for this purpose, where the lines are suspended and dried.

When completely dry, the shot lines are faked in their boxes, and the lines rove upon their reels and placed on the cart; everything must be replaced ready for service.

This coiling of the large lines must be done with care to avoid tangling and turns. All kinks and turns should be removed in coiling up.

(9) DRILLS.

As soon as a drill has been given under the direction of an inspector of the Société Centrale de Sauvetage des Naufragés, the officers will complete the instruction of their men by drills as frequently as possible.

When the instruction is judged to be sufficiently perfect the drills will only be repeated quarterly.

For firing with projectiles it is recommended to choose soft ground; for the establishment of the breeches buoy it is better to have it over water. The weight of the apparatus and the friction of the lines is almost nothing there, while on land the hauling would be very painful. Besides, the operation on land would not present the same effects as in the water, where one would learn to watch still more to prevent the tangling of the lines.

If the place does not permit of a line being thrown by a projectile, it may be carried by hand to the place representing the wreck, in order to haul out the whip line. The buoy will be passed back and forth several times.

When in localities where line-carrying guns are established in basins, the drill may be executed from the quay to one of the vessels

in the vicinity; if the station is on an isolated beach it is useful to procure a good mast and erect it at a suitable place, with the rigging desired, and to fasten there the hawser and the whip line.

Persons kindly disposed may join the personnel of the customs and assist at the drills, but the chief of piece and the crew will always be taken from among the customs officials. Similarly, the drills, etc., will always be made under the direction of the customs officers of the locality. They must apply immediately after each drill for repairs or replacements necessary, in order that all the material may always be in serviceable condition.

PACKING AND TRANSPORTATION OF APPARATUS.

(Plates LXII AND LXIII.)

The line-throwing and breeches-buoy apparatus is placed upon a cart for transportation to the scene of the wreck. The felloes of the wheels vary in breadth, depending on the nature of the soil to be passed over within the range of operations. A pair of shafts are provided for attaching a draft horse, and also men's harness to be used in cases where the distance is short or a horse not available. The sides and bottom of the body are made of strips of pine placed a few centimeters apart, to lighten the weight of the cart as much as possible. The front and rear ends are made in the same manner, and can be removed at will. They are fastened by catches and bolts.

The whole apparatus must be kept carefully packed in the cart and in constant state of repair and readiness for use. Although at times the whole of the apparatus may not be absolutely needed, it is necessary to have at all times the appurtenances ready for service in case they are required.

The several objects are packed in the cart so that those first required on arrival at the scene of operations may be on top. Thus, on the bottom of the cart the hawser is coiled flat the whole length and breadth of the cart, with the signal flag and staff. Above this first layer is stowed the rope and tackle, and in the space between its turns the sand anchor, shovel, pickaxe, snatch block, and directing pulley No. 1. The third layer is formed by the whip line divided into two large coils equal to the width of the cart with the pulley and swivel between them, and on the top the breeches buoy in the middle; in the empty spaces at the corners are placed the heaving lead and line, the wooden tablets, the canvas pouch, the implement pouch, the box with cartridges, etc. The projectiles and the sponge are placed along on each side. On top, resting on the sides of the body, are the faking boxes with the shot lines.

The greatest care must be taken in coiling and packing the whip line to prevent its getting tangled during hasty or rough handling, by fastening the parallel portions of line together at several points with small twine.

The ironwork of the cart, pulleys, the gun carriage, and tripod must be kept in good condition, painted, oiled, and greased according to the case, and the lanterns must be kept supplied with candles.

The carts thus loaded are covered with a tarpaulin fastened at the sides to prevent the friction or rubbing of the wheels from cutting the canvas, the men's harnesses attached, and the shafts dismounted.

The gun mounted on its carriage can be attached in rear of the cart and taken to the place of the wreck when the road is practicable, otherwise it is hauled separately.

With this arrangement, one has only to go to the scene of the wreck and can be certain of having all the apparatus that is necessary in readiness for immediate use.

SHELTER.

All the material belonging to the life-saving stations of the first class is stored in establishments belonging to the public service or in the shelters or stations constructed by the "Société Centrale de Sauvetage." The minimum space required is 5 meters (16.4 feet) long by 4 meters (13.2 feet) wide, with double doors 2 meters (6.56 feet) high and 2.3 meters (7.55 feet) wide.

These shelters or stations are made of wood, brick, or stone, as most convenient and economical in the region where placed. When built of wood, the structure is placed on a brick or masonry foundation extending from 25 to 30 centimeters (10 to 12 inches) above the level of the soil. The floor is either cemented, macadamized, or paved, and has a slight slope toward the door to permit easy drainage. The best covering for the roof is zinc.

The door has duplicate keys. It is well to have, if possible, a small entrance door at the rear end of the station. The lock can be attached to this door and the leaves of the double door can be fastened by means of a lever or crossbar on the inside. One or several shelves serve to hold the small objects about the station used for repairs, etc. Copper hooks on the walls support the life belts when they are moistened or are too wet to be placed on the cart with the rest of the apparatus.

At the time of the reception of the several components of the apparatus the ropes are several times moistened, dried, and stretched until they are pliable and will not kink or twist.

INVENTORY OF APPARATUS SUPPLIED TO LIFE-SAVING STATIONS OF THE FIRST CLASS.

(1) *Line-carrying apparatus.*

	No.
1. Perrier gun	1
2. Gun carriage with elevating quoin.	1
3. Projectiles with shanks	5
4. Shot lines 7 millimeters 350 meters long	3
5. Shot lines 5 millimeters 450 meters long	2
6. Faking boxes No. 1	3
7. Faking boxes No. 2	2
8. Sponge ladle	1
9. Powder measure	1
10. Gunner's pouch	1
11. Priming wires	2
12. Lanyard	1
13. Quadrant	1
14. Box for cartridges	1
15. Powder can	1
16. Target poles	2
17. 10-meter measure (metallic)	1
18. Powder C [1]	sufficient supply
19. Cartridges and cartridge bags	do
20. Wads	do
21. Friction primers	do

(2) *Breeches-buoy apparatus and miscellaneous appliances.*

	No.
1. Double whip line 16 millimeters (0.63 inch) diameter	1
2. Pulley with tail and swivel	1
3. Hawser 28 millimeters (1.1 inch) diameter *	1
4. Directing pulley No. 1 *	1
5. Directing pulley No. 2	1
6. Breeches buoy	1
7. Fall and tackle 27.5 millimeters 45 meters long—hemp *	1
8. Double pulley with hook for tackle *	1
9 Double pulley with double tail for tackle *	1
10. Tripod *	1
11. Snatch block with swivel *	1
12. Anchor pile shod with iron †	1
13. Wooden crossbar for sand anchor †	1
14. Shovels	2
15. Pickax *	1
16. Maul with handle *	1
17. Lantern (for candles) with red and white glasses	1
18. Lantern (hand)	1
19. Red signal flag and staff	1
20. Canvas bag	1
21. Belaying pin for splicing ropes	1
22. Tally boards, No. 1	3
23. Tally boards, No. 2	3
24. Ball of tarred twine	1
25. Heaving lead and line	1
26. Life belts	2
27. Copper hooks for life belts	6
28. Oil can	1
29. Box lubricating grease	1
30. Apparatus cart	1
31. Sets men's harness	2
32. Pair of shafts	1
33. Drill mast	1
34. Instructions for life saving-stations of first class	2

* These articles are not furnished stations where the hawser can never be used.

† These two objects may be replaced by any device most convenient to serve as an anchor.

CHAPTER II.

APPARATUS AND EQUIPMENT OF A LIFE-SAVING STATION OF THE SECOND CLASS.

(Plate LXIV.)

The nomenclature and employment of the objects entering into the composition of a station of the second class are as follows:

(1) *Heaving lead.*—This instrument serves to carry a 6-millimeter (0.24-inch) line to a distance 20 to 30 meters (65.6 to 98.4 feet), and to establish a communication between the shore and a stranded vessel; the weight of lead is 650 grammes (22.9 ounces).

(2) *Floating lead.*—This is a stick loaded with sufficient lead at one end to maintain it in a vertical position in the water and is employed for the same purpose as the heaving lead and in case of necessity can be thrown to a person in danger of drowning and will assist in supporting him in the water.

(3) *Heaving line.*—This line is 6 millimeters (0.24 inch) in diameter and 120 meters (394 feet) long. It is used for attaching to the heaving lead, and may be fastened to the life belt when one of the crew wearing it goes to the rescue of wrecked persons.

(4) *Tow-line.*—This line is a line 10 millimeters (0.39 inch) in diameter and about 150 meters (492 feet) long, used as a secondary line to replace the line employed to establish communication with the stranded vessel, and to haul the whip line on board.

(5) *Life belts.*—These are designed for those of the crew who are obliged to enter the water in working at a wreck.

(6) *Brass hooks.*—These are to hang the life belts on in the stations.

(7) *Instructions upon a board.*—This board is posted on the walls of a station and contains the instructions relative to the employment of life belts.

These objects should be hung in an easily accessible position on the wall and arranged in the following manner:

The board with instructions between the two life belts; the heaving lead and line on the left, the tow-line on the right. (See Plate LXIV.) The rampart gun and the equipment box shown at the top and bottom of this plate, respectively, belong to the outfit of a second class station alone; the others form the equipment of a third class station.

(8) *Instructions.*—Two copies of instructions upon the service of life-saving stations of the third class.

In addition to the above the equipments of a station of the second class comprises:

(9) *A rampart gun* used to throw lines by means of an arrow-like projectile to a distance of 70 or 80 meters (230 to 265 feet) to establish communication between the shore and stranded vessel.

(10) *Wooden case.*—Closed by two padlocks and containing the articles enumerated below.

(11) *Arrows.*—With ties or fastenings and sliding knot intended to carry out a line of two or three millimeters 0.08 or 0.12 in diameter in order to establish communication with a stranded vessel, a pier, or a person in danger of drowning.

(12) *Powder flasks.*

(13) *Greased wads.*

(14) *Canvas bag to hold the wads.*

(15) *Ball of line* 20 meters (66 feet) long and 4 millimeters (0.16) diameter for replacing the tie loops and sliding knots used up or injured.

(16) *Balls of shot line* 150 meters (492 feet) long; three of 3 millimeters (0.12) in diameter and one of 2 millimeters (0.08) in diameter.

(17) *Conical mandrels* for balling the lines.

(18) Small barrels of cylindrical cases furnished with suspenders to be worn like a shoulder belt. These cases carry the shot lines and permit the wearer to advance into the water as far as possible before firing.

(19) *Line with corks.*—This line has corks strung along its length to float it in the water. It is thrown to persons endeavoring to reach the shore by swimming.

(20) *Ball of tarred twine* for selvages.

(21) *Tin Boxes.*—One for lubricating grease and one for percussion caps.

(22) *Metallic box.*—Closed with a screw cap, to contain the supply of powder, about one kilogram (2.2 lbs.).

(23) *Ten-meter measure.*—For measuring lines and verifying the ranges and deviations in firing drills.

(24) *Poles.*—These are 4 to 5 meters (13 to 16 feet) high to serve as a target in firing drills. They are bought at the stations.

(25) Instructions for stations of the second class.

The arrangement of the material is the same in second and third class stations. The hand gun may be put in the rack with the arms of the customs officials and the equipment box upon two perches or brackets, 40 or 50 centimeters (15.75 to 19.68 inches) above the ground or floor. In case there is no arm rack the piece will be placed horizontally with the lock plate outward above the life belts, as shown in the plate.

INSTRUCTIONS FOR USING THE LINE-CARRYING SMALL ARM.

(Plate LXV.)

THE PIECE.

The hand guns or small arms now provided to the stations along the coast are the old rampart guns, model of 1840 and 1842. They were utilized from economical motives. The weight of the piece is 5.5 kilograms (12.12 pounds); the caliber, 21.5 millimeters (0.836 inch).

The cylindrical breech-chamber is 14 millimeters (0.551 inch in diameter and will contain 7 grams (108 grains or 0.247 ounce) of powder.

The weight of the arrow-like projectiles is from 280 to 300 grams (9.87 to 10.6 ounces). The powder charge should not exceed 5 grams (77.3 grains), in order not to have too much recoil or to risk breaking the line by the velocity this charge would impress upon the arrow. The most suitable charge for ordinary conditions is from 3 to 4 grams (46.3 to 61.7 grains). In case of necessity, and depending on the nature of the powder, the charge will be carried to 4.5 or 5 grams (69.4 or 77.3 grains).

For preliminary drills a charge of 2 grams (30.8 grains) will be sufficient.

The empty space in the chamber presents no inconvenience, but when charges of 2 to 3 grams (30.8 to 46.3 grains) are employed a small wad should be introduced in the chamber to retain the powder at the bottom, as sometimes the percussion cap drives the grains of powder forward without igniting the charge.

THE ARROW.

(Plate LXVI.)

The wooden arrow is perfectly straight and cylindrical, 47 millimeters (1.85 inches) in diameter. Its length is 1.1 meters (43.31 inches). It will float on the water. The ends are armed with copper sabots 19.5 millimeters (0.77 inch) in diameter and held by pins.

The shoulders formed by the difference in diameter of the sabots and shaft serve as stops to arrest the sliding knot and ties as they slide along the shaft in firing.

The sliding friction by which the inertia of the line is gradually overcome is the base of Delvigne's system.

THE SLIDING KNOT.

(Plate LXVI.)

This knot or slider is made by six or seven turns of 4 or 5 millimeter (0.157 or 0.20 inch) line, taken in the same way that fishermen fasten a fish-hook to a line. (See plate).

This knot must be tight enough to require a certain effort to make it slide along the shaft of the arrow, previously greased or oiled.

It is upon the degree of this compression or tightness that depends, in great part, the success of the firing.

This necessitates a rather delicate adjustment, which only practice will secure.

THE TIES OR FASTENINGS.

Upon the sliding knot pushed to the front end of the shaft are placed two fastenings or ties, intersecting and embracing the shaft. The ties are formed by splicing the two ends of a piece of line about 35 millimeters (13.78 inches) long; or, which is preferable, by untwisting the threads of a rope's end about one meter (3.28 feet) long, in order to re-form of each strand a strap or selvage with three strands, as was the original line.

It is to the end of these two ties united that the shot line is attached. (See plate).

THE SHOT LINES.

The size of line used generally is 3 millimeters (0.12-inch) in diameter. By using a 2-millimeter (0.08 inch) line the range is increased from 10 to 15 meters (10 to 16 yards).

The line is wound or coiled upon a mandrel slightly conical, about 25 centimeters (9.84 inches) long and 4 to 5 centimeters (1.57 to 1.96 inches) in diameter. in the same manner that sailors lay up or "ball" spun yarn.

After having fastened the end of the line to the lower end of the mandrel, so as to be able to detach it easily, the line is rolled around the middle of the mandrel over a length of 6 or 7 centimeters (2.36 or 2.75 inches) and then by superposed layers to form the nucleus or seat around which will be rolled the line.

This seat should be slightly oval in form, in order that the finished ball may have that form. A ball too long will collapse before it is completely emptied, which does not occur when the last coils have the arched form.

The line is wound obliquely from right to left upon this seat, by drawing it a little and each time turning the mandrel in the inverse direction.

The ball being formed, it is secured by working three or four turns crosswise, drawing it strongly and looping the doubled end under the last turn or coil.

The mandrels are left in the balls until the moment of firing, in order that the balls may not be deformed.

When the mandrel is withdrawn from the ball, care must be taken to draw out a few yards of the line from the side toward the large end of the mandrel.

If the line be pulled out from the other end it will knot and kink and come out in bunches, which will diminish the range and may break the line.

PRECAUTIONS FOR PRESERVING THE SHOT LINES.

After each drill or wreck, the lines should be well dried, straightened out, untwisted and have the kinks removed, and then re-coiled in balls. The lines should not be dragged over the sand or ground. The member of the crew who, at drill, goes out to recover the arrow or projectile picks up the line on his return, in order to avoid the friction and wear incident to hauling in from one end, which soon wears out or cuts the line.

THE SHOT-LINE CASE.

As it may happen that the firer is obliged to advance into the water in order to approach as near as possible the wreck, a small barrel or case with a shoulder belt is supplied to carry the ball of shot line.

The ball is retained in the case by two cords which prevent its falling in the water.

METHOD OF EMPLOYMENT.

Loading.—Before loading see that the vent is clear. Then pour in the powder charge and introduce a wad, pressing it down with a ramrod or the arrow itself, but *without ramming.*

The arrow must be slightly greased. Over the sliding knot fasten the ties or loops to which the shot line is attached *by three or four loose turns and then made fast by two or three half-hitches.*

It is indispensable to wrap around the loops at the bearing point of the line some elastic body—linen, tow, grass, or soft paper—to ease the pressure of the line upon these loops.

The ball of shot line is placed upon the ground, to the right or to leeward, and the shore end of the line attached to a picket, stone, or other fixed object, to prevent the ball being carried off in the event of a tangle or knot forming in the line.

It is advantageous to elevate the front end of the ball slightly by placing something under it, so that the running out of the line may take place as nearly as possible in the direction of the line of fire.

It is important to press the piece firmly against the shoulder in firing to diminish the recoil, which is quite strong.

RANGE AND FLIGHT OF THE ARROW.

The range of the gun does not exceed 70 to 80 meters (77 to 88 yards) with the 3-millimeter (0.12-inch) line; with the 2-millimeter (0.08-inch) line a range of 90 to 100 meters (98 to 110 yards)

may be obtained. These ranges may be very perceptibly influenced by the direction and force of the wind.

With the elongated projectile that Mr. Delvigne calls flèche (arrow) great accuracy of fire is obtained. It is necessary, however, to be on guard against lateral deviations, which affect the line, especially when the wind does not blow in the direction of the plane of fire.

It is necessary to try to fire, when, possible, with the wind, in order to increase the range. If these conditions can not be secured the piece must be aimed so that the line will fall across the object or vessel.

The proper allowances for direction and elevations can only be obtained by practice drills.

In calm weather, light breeze, or cross winds, the elevation given to this piece is from 25 to 30 degrees. With a rear wind the range is considerably increased; the firing is done under a higher angle, and the stronger the wind the greater the angle of elevation, as the wind has as much effect upon the range as the powder charge itself.

With a wind directly against the firer the angle of elevation must be less than 25 degrees.

When the arrow leaves the bore of the piece, the sliding knot and loops slide with friction along the shaft until they bring up against the shoulder of the rear sabot; this friction diminishes the shock and avoids the rupture of the line which is thus set in motion progressively.

When the line has been seized by the wrecked crew, the towline or intermediate line is bent on and paid out carefully as the crew haul it on board.

CARE OF MATERIAL.

After each wreck or drill, all damages are repaired, the objects used are dried and laid in order in the equipment chest, all ready for instant service. The arrows will be slightly greased with tallow or suet so that the rain or humidity may not penetrate the wood and that the sliding of the knot may take place without stoppage.

PACKING.

The arrows are placed flat on the bottom of the case to avoid bending, which would affect their flight. The shot-line cases with the line in position will be placed above the arrows and to the left, then the balls of line, etc., and the powder at the right-hand end of the case.

EMPLOYMENT OF LINE WITH CORKS.

This line is designed to be thrown out to succor a person struggling in the water. One end of the line with corks is fastened to the arrow and the other to the end of the shot line in the ball. The

line furnished with cork buoys is stretched out in the direction of the line of fire to prevent breaking or tearing off the corks.

The piece must be aimed so that the line supported by corks may fall as close as possible to the person to be assisted, and to the leeward of him rather than to the windward.

Inventory of apparatus supplied to a life-saving station of the second class.

	No.		No.
1. Heaving lead	1	14. Canvas bag for wads	1
2. Floating lead	1	15. Ball of line, 4 millimeters, 20 meters long	1
3. Heaving line, 6 millimeters diameter, 120 meters long	1	16. Balls of line, 150 meters long: 3 millimeters diameter	3
4. Towline, 10 millimeters diameter, 150 meters long	1	2 millimeters diameter	1
5. Life belts	2	17. Conical mandrels	3
6. Brass hooks	6	18. Shot-line cases with shoulder belts	2
7. Instructions mounted on board.	1	19. Line with cork buoys	1
8. Instructions for third-class stations	2	20. Ball of tarred twine	1
9. Rampart gun (shoulder use)	1	21. Small tin boxes	2
10 Equipment case (two padlocks).	1	22. Metallic case for powder	1
11. Projectiles (arrows) with ties and sliding knots	8	23. Ten-meter measure	1
12. Powder flasks	2	24. Poles for drill target	2
13. Greased wads	100	25. Instructions for stations of second class	2

Inventory of apparatus supplied to life-saving stations of the third class.

	No.		No.
1. Heaving lead	1	5. Life belts	2
2. Floating lead	1	6. Brass hooks	6
3. Heaving line, 6 millimeters, 120 meters long	1	7. Instructions for use of belts mounted on board	1
4. Towline or intermediate line, 10 millimeters, 150 meters long	1	8. Instructions for service of third-class stations	2

This apparatus has been explained in the preceding pages, in treating of stations of the first and second classes.

CHAPTER III.

INSTRUCTIONS FOR LIFE-SAVING STATIONS.

GENERAL OBSERVATIONS APPLICABLE TO ALL STATIONS.

(1) The "Société Centrale de Sauvetage des Naufragés" has established and maintains along the coast a certain number of relief and life saving-stations for stranded mariners.

(2) The handling and maintenance of the apparatus for life-saving purposes are confided to the customs service, which has very kindly accepted this mission.

(3) The officers of the customs service are charged with the superintendence of the stations. They should make themselves familiar as soon as possible with the handling of the apparatus, in order to be able to instruct and direct the men of their division.

(4) An inspector of the society inspects the life-saving stations. He gives to the officers all the necessary explanations; he assures himself that the apparatus is in good condition and the crews well drilled.

INVENTORY OF APPARATUS.

(5) When a life-saving station has just been established, the keeper has an inventory drawn up of the apparatus which has been sent to him.

He sees that the lines have the length and diameter designated, and sends, through the official channels, to the Society, a detailed report, with observations if there be any.

Each object sent from Paris bears a parchment label indicating the number of the article in the general nomenclature.

At the time of the reception of the material, the cordage and lines are moistened several times, dried and stretched until they are pliable and will not kink or knot.

REQUISITION FOR AMMUNITION.

(6) At life-saving stations of the first and second classes the keeper provides himself with ammunition by sending to the nearest director of artillery, through the official channel, a requisition made on blank No. 7, which also serves for subsequent requisitions for similar supplies.

DRILLS.

(7) When the apparatus has been verified, and after the reception of the ammunition, the drills commence. They are, as far as possible, directed by an officer, and all the men available are present at them.

(8) They should be sufficiently frequent to make the crew, as soon as possible, familiar with the apparatus confided to them.

(9) When the instruction is complete it is sufficient to have drills quarterly at stations of the first class, and twice quarterly at stations of the second and third classes.

(10) After each drill a report, blank No. 6, will be sent to the directors of customs.

At the end of the quarter these reports will be transmitted through the general direction to the delegated manager of the "Société Centrale de Sauvetage."

OPERATIONS AT WRECKS.

(11) Whenever the men on watch along the coast see a vessel in a dangerous situation, and when they fear a disaster, they will warn the keeper, who will send a telegram, at the expense of the Society, to give the alarm to the life-boat station or to the nearest station possessing line-throwing apparatus.

(12) The customs crews should never hesitate to go out with their life-saving apparatus when a wreck is to be feared. They betake themselves as soon as possible to the point on the coast where their services can be utilized.

(13) Every time that the customs crews go out with their life-saving apparatus or to carry assistance to stranded mariners or even in anticipation of a disaster they have the right to the indemnity specified on the back of the blank No. 5, which in this case must be sent immediately to the society, accompanied by the report on blank No. 5.

(14) In the column of observations will be noted any improvements that practice with the apparatus will have suggested to the agents who have just used it.

MAINTENANCE OF APPARATUS.

(15) Every time the apparatus is used it will be replaced in perfect order; the lines and ropes will be well dried, straightened, and faked or coiled.

(16) The material should be aired at least once per month. In the stations of the first class the door of the station will be opened on fine days and the cart will be placed outside for some hours.

(17) As soon as any piece of apparatus is unserviceable the fact is brought to the attention of the society, who will have it replaced.

The damaged object is put aside and continues, if it be possible, to be employed in the drills.

EXPENSES.

(18) The expenses necessary to keep up the apparatus may be authorized directly by the customs officers in active service, not to exceed the sum of 30 francs (about $6) per year for stations of the first class, and of 5 francs (about $1) for those of the second and third classes.

(19) If the repairs or new installations require a greater sum, an estimate must be sent to the society and the work be undertaken only after its approval.

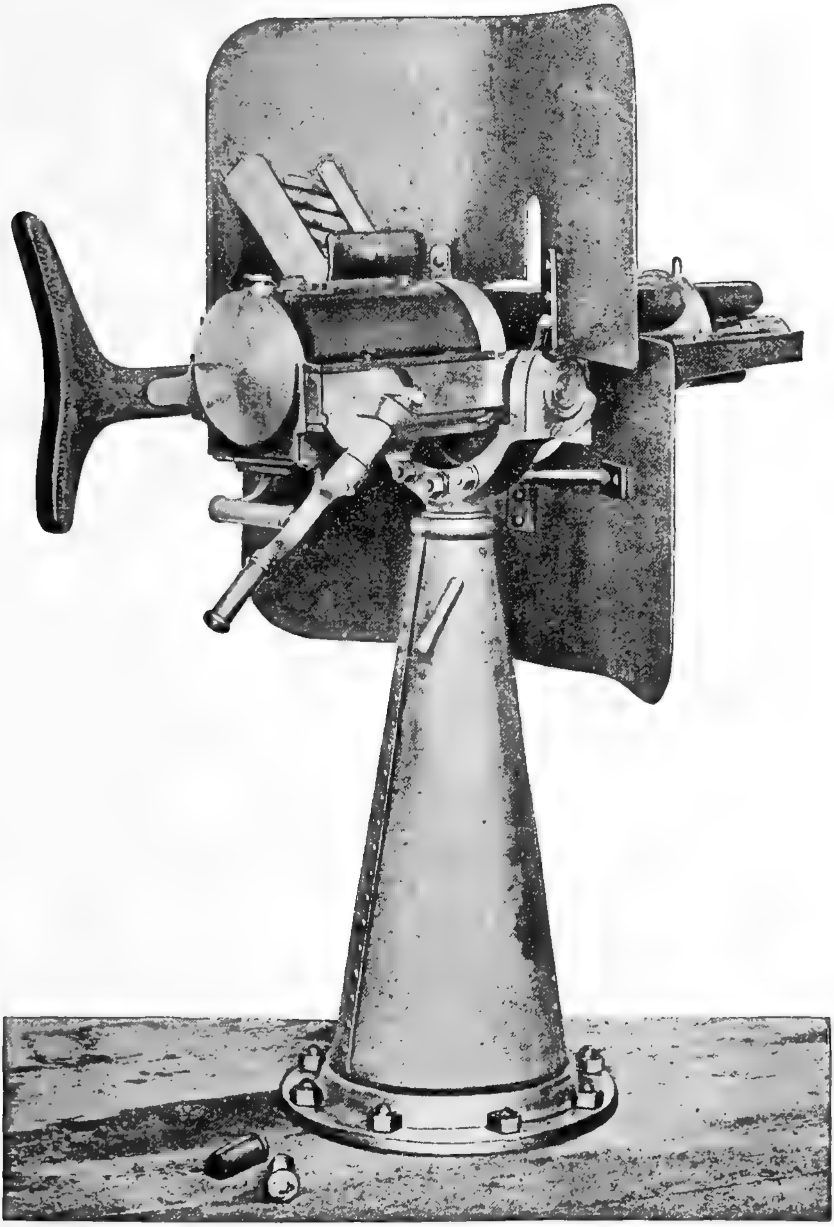
(20) In every case a report of expenses, blank No. 8, will be drawn up by the officer who ordered them; it will be accompanied by invoices and indorsed by the inspector of customs.

(21) The expenses necessitated by the salvage service are paid by the receivers of customs, who cover themselves for their disbursements through the principal receiver in Paris, who is in account current with the society.

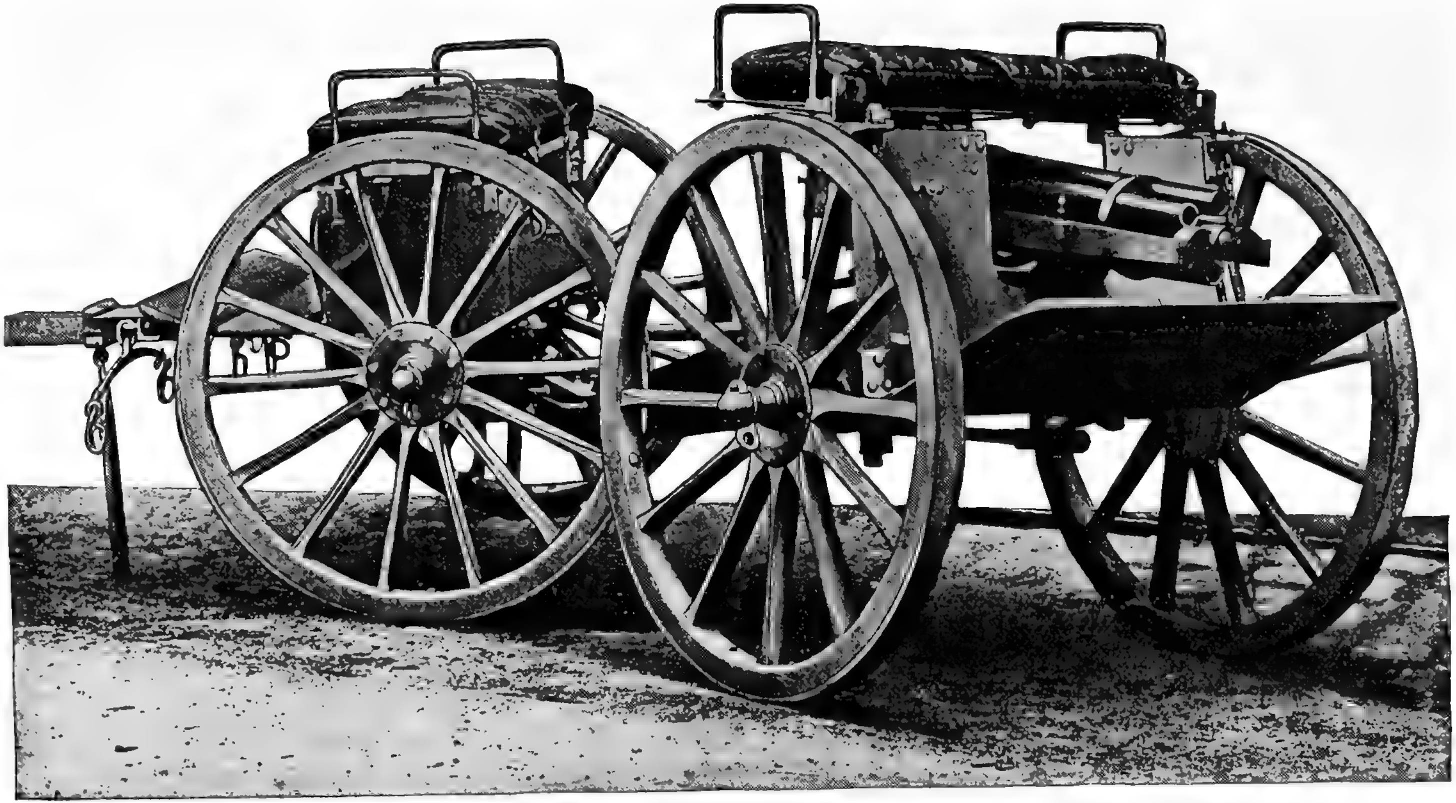
(22) Printed blanks Nos. 5, 6, 7, and 8 are deposited with the chief clerks of the directions. It is to them that the keeper makes application for blanks as necessary.

(23) There is kept in each station a special register in which are entered the results of the drills and wreck operations, the observations made on the working of the apparatus, the consumption of ammunition, the loss or injury of articles in use, and expenses of every kind.

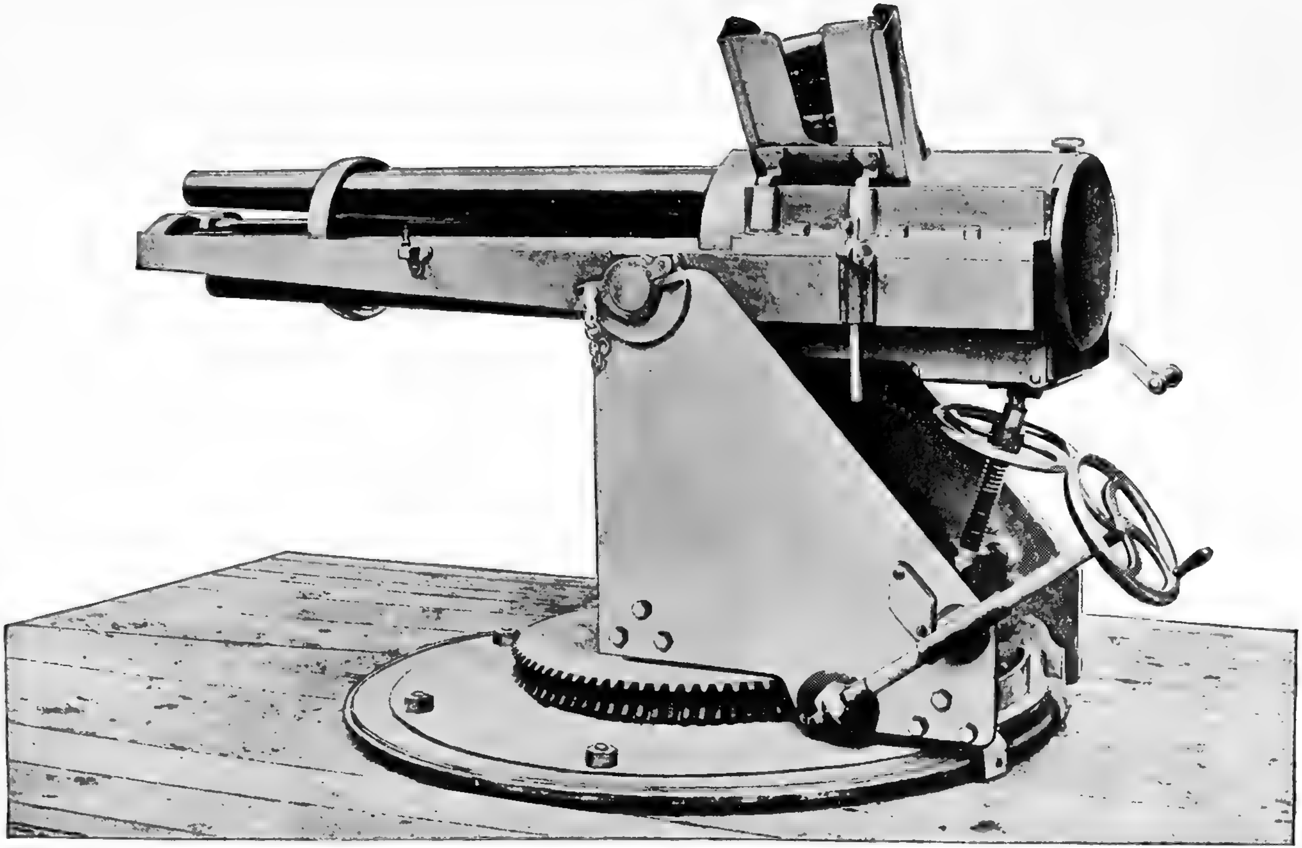
(24) These instructions replace all those which have been previously published.



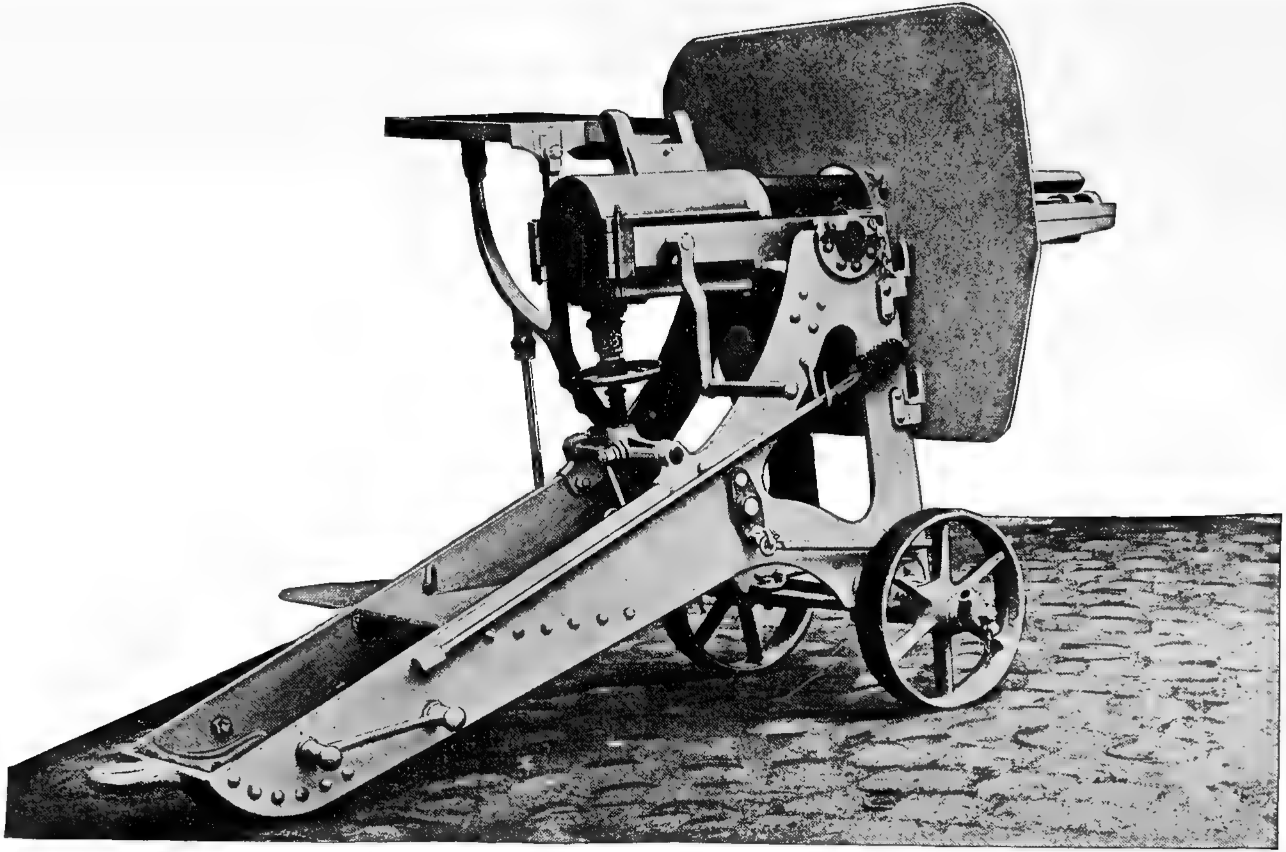
LIGHT 37-MILLIMETER HOTCHKISS REVOLVING CANNON ON CONICAL SUPPORT WITH SHIELD.



LIGHT 37-MILLIMETER HOTCHKISS REVOLVING CANNON MOUNTED ON FIELD CARRIAGE, WITH SHIELD AND LIMBER.

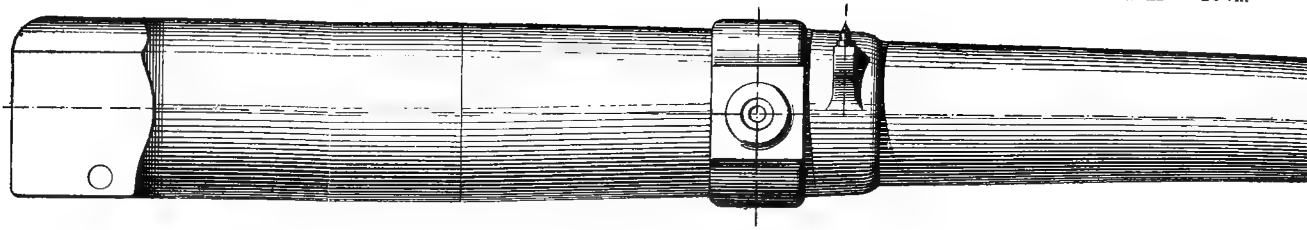


53-MILLIMETER HOTCHKISS REVOLVING CANNON MOUNTED ON CENTER-PIVOT CARRIAGE.

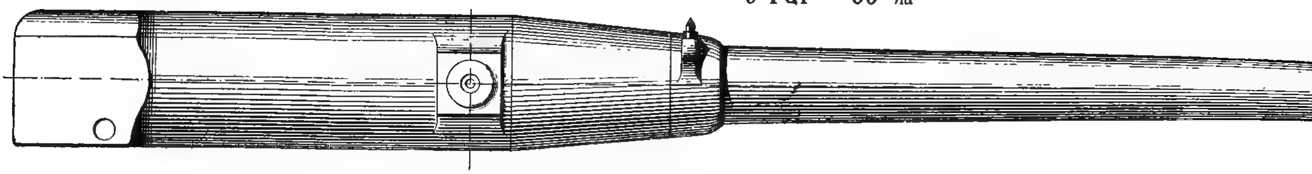


40-MILLIMETER HOTCHKISS REVOLVING CANNON MOUNTED ON FLANK DEFENSE CARRIAGE.

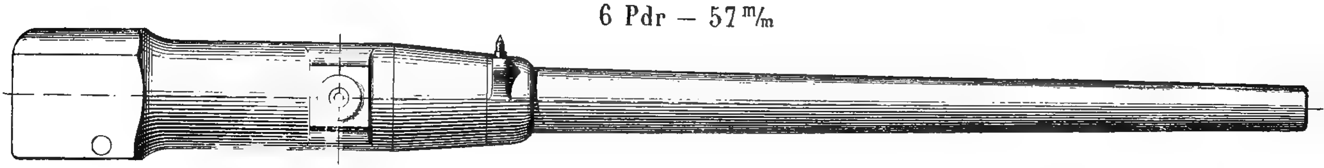
33 Pdr — 10 c/m



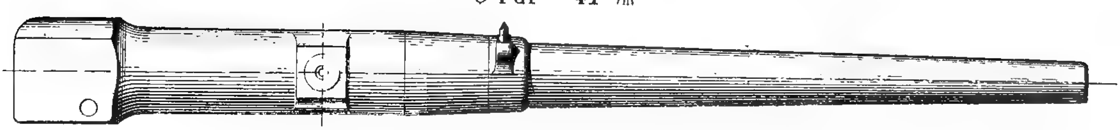
9 Pdr — 65 m/m



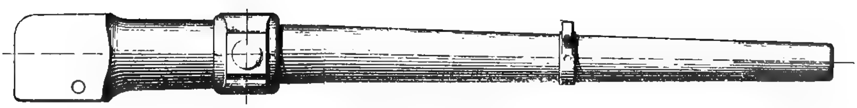
6 Pdr — 57 m/m



3 Pdr — 47 m/m



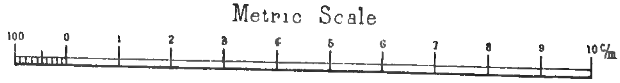
2 ½ Pdr — 47 m/m



1 Pdr — 37 m/m

Me	
37 m/m	47 m/m
37	47
33	120
842	1557
740	1410
18	28
505	1122
80	200
402	444

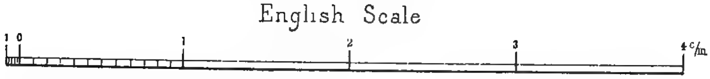
Metric Scale



HOTCHKISS RAPID-FIRING GUNS.

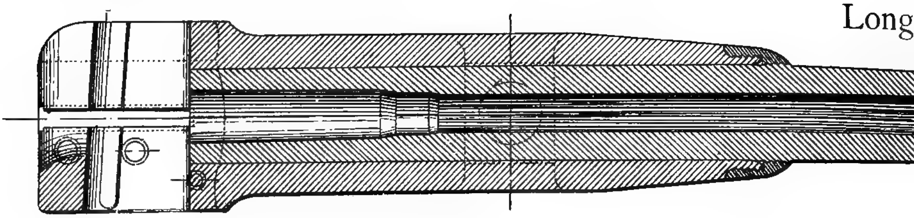
ic Measure							English Measure					
47 m/m	57 m/m	65 m/m	10 c/m				33 pdr	9 pdr	6 pdr	3 pdr	2½ pdr	1 pdr
47	57	65	100	m/m	Caliber	in	3.94	2.56	2.24	1.85	1.85	1.46
230	365	610	1600	k^os	Weight	lbs	3520	1342	805	507	264	73
048	2480	3025	4410	m/m	Total Length	in	173.6	119.1	98.	81	61	.33
881	2280	2833	4160	m/m	Length of Bore	in	163.7	111.5	90.	74	55	29
31	35	·37	35	cal	Travel of Shell	cal	35	37	35	31	28	18
511	2724	4000	15000	gr	Weight of Shell	lbs	33	8.8	6.	3.32	2.47	1.1
780	895	1550	5700	gr	Weight of charge	oz	200	54.56	31.5	27.53	7.06	2.82
610	610	590	600	mètres	Initial Velocity	ft	1970	1935	2002	2002	1457	1319

English Scale



BO

Long



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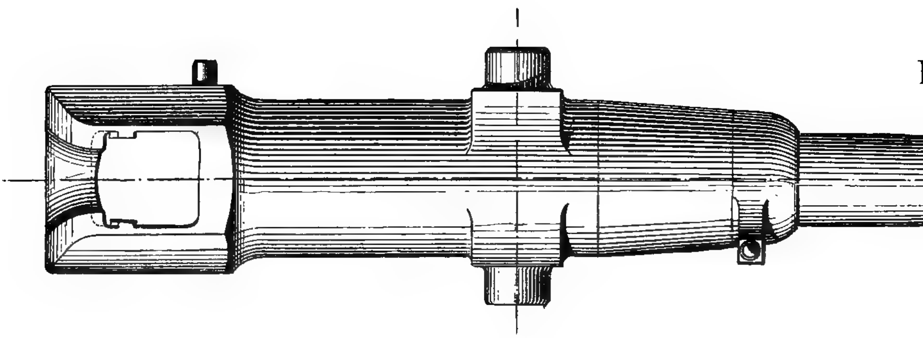
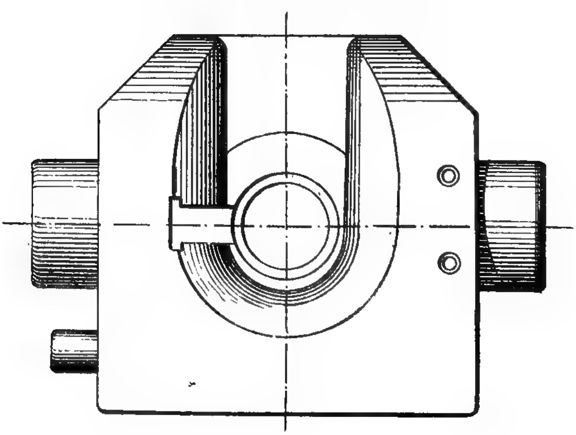
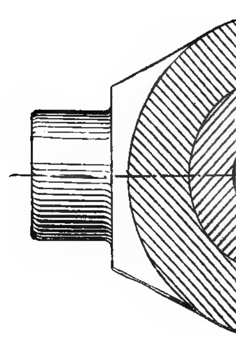


Breech Elevation



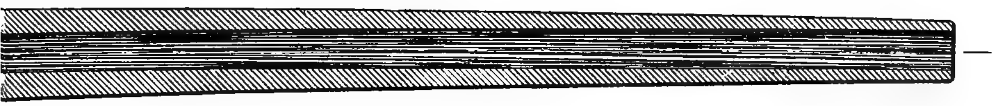
Cros



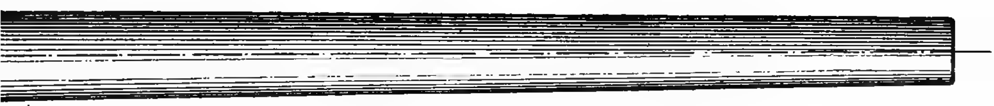
HOTCHKISS

IDY OF GUN.

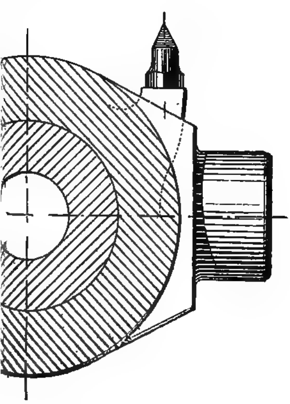
tudinal Section.



'rofile.

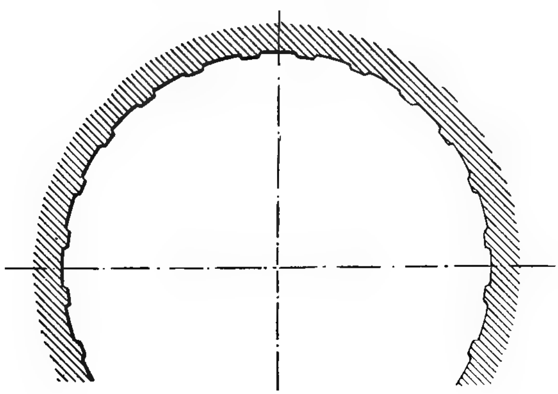


Section.



Profile of Rifling.

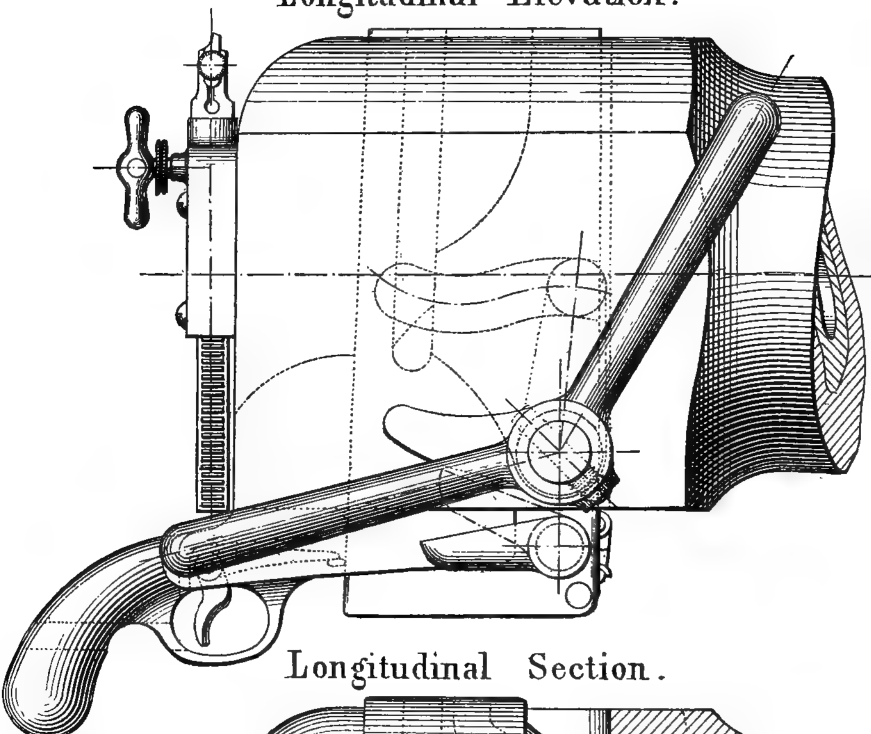
Full Size - 6.Pdr.



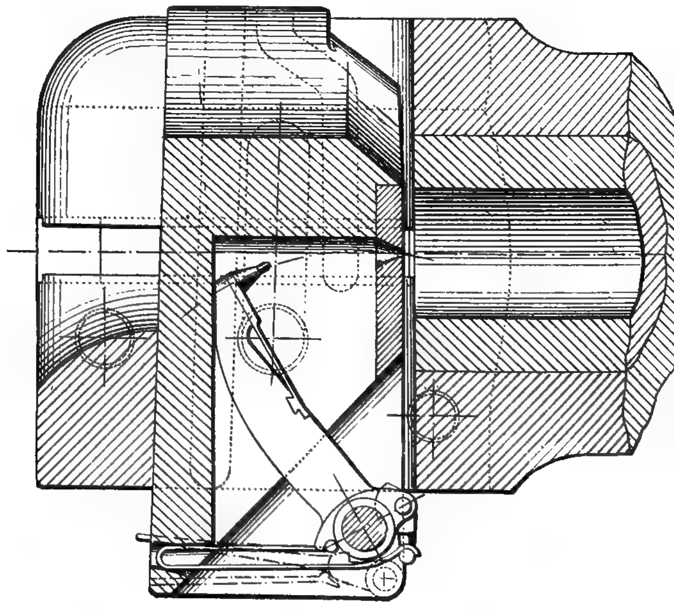
RAPID-FIRING GUNS.

BREECH AND M

Longitudinal Elevation.

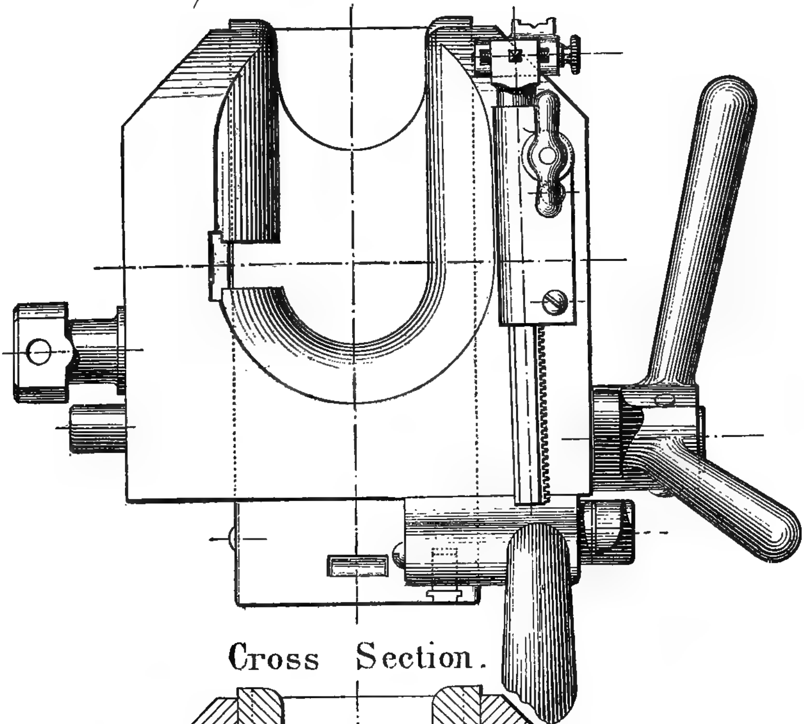


Longitudinal Section.

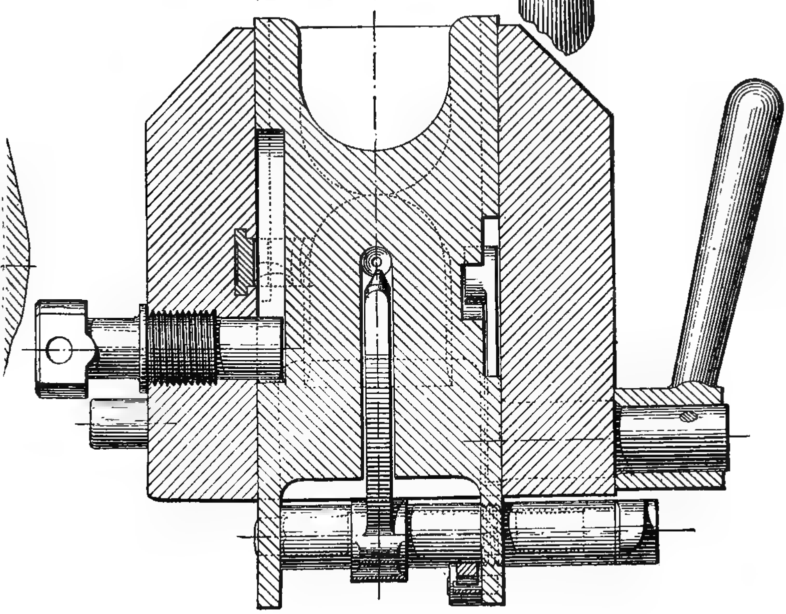


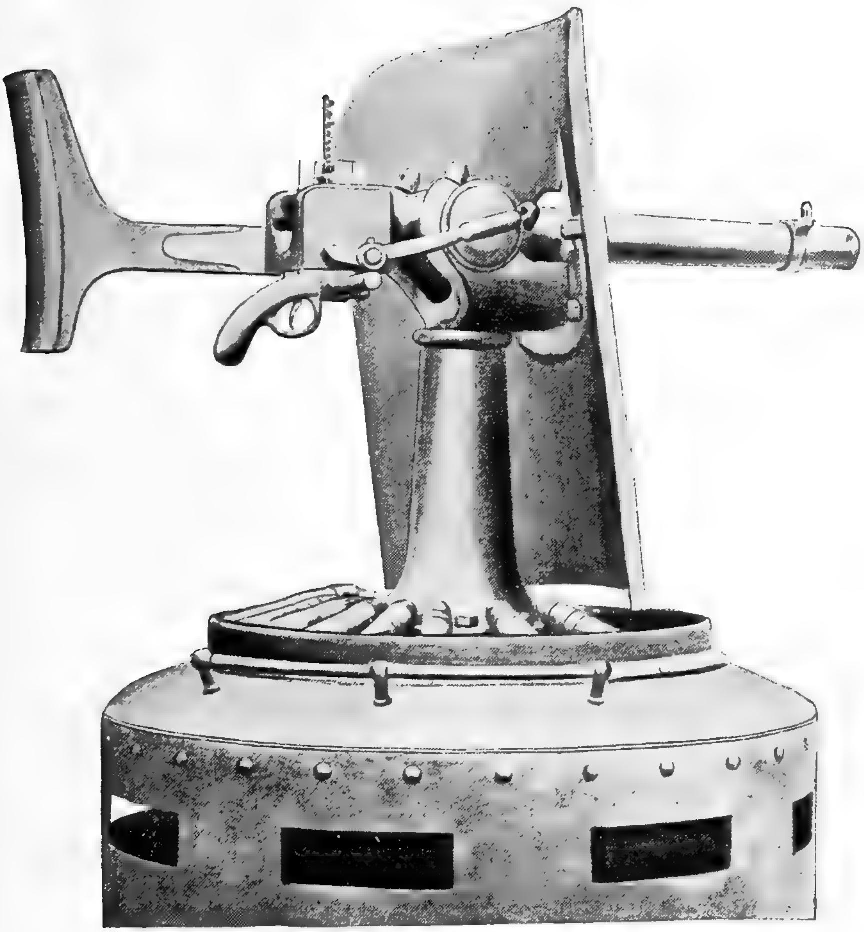
HOTCHKISS RAPID-

Rear Elevation.

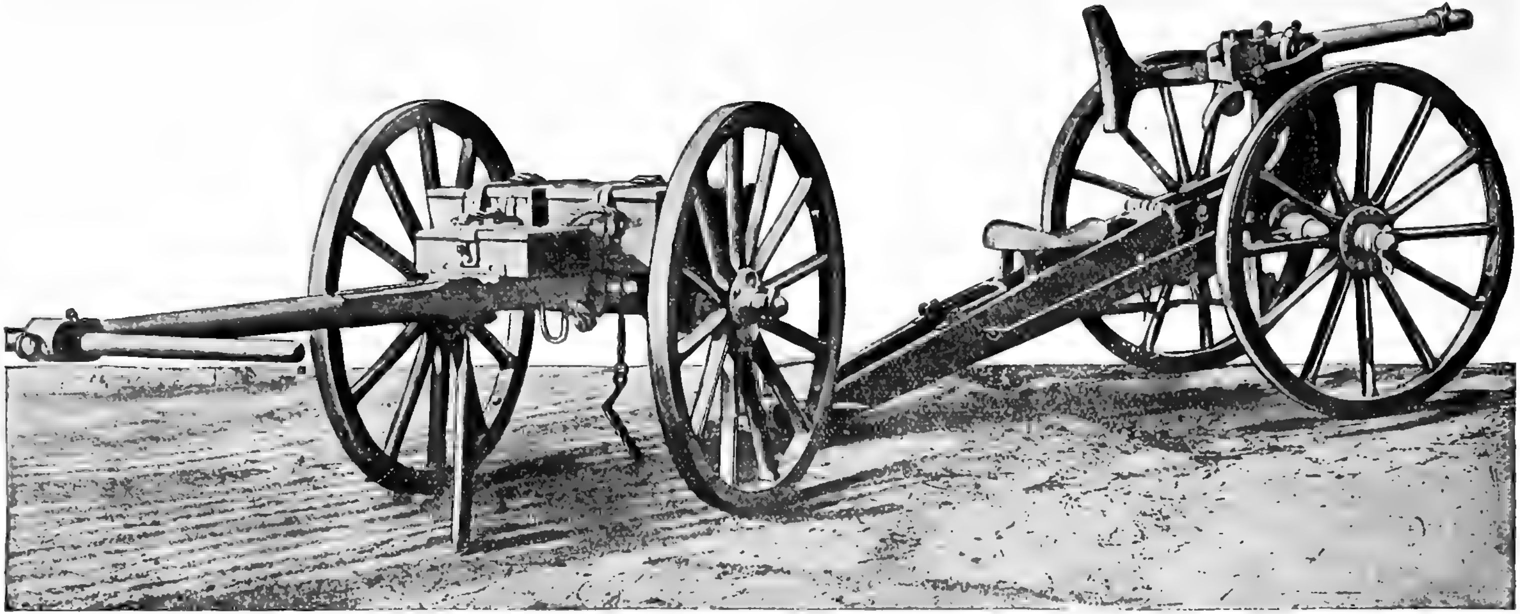


Cross Section.



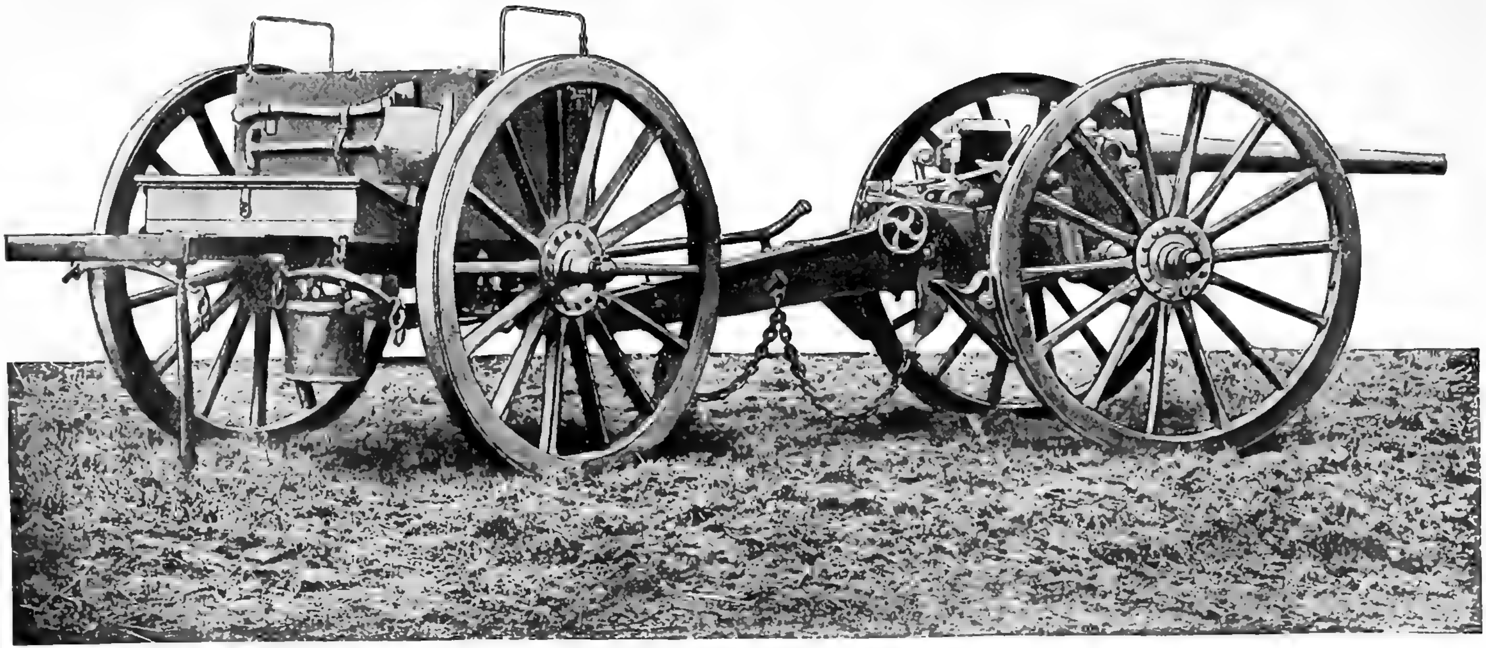


LIGHT 37-MILLIMETER HOTCHKISS RAPID-FIRING GUN ON A PIVOT CARRIAGE WITH SHIELD.

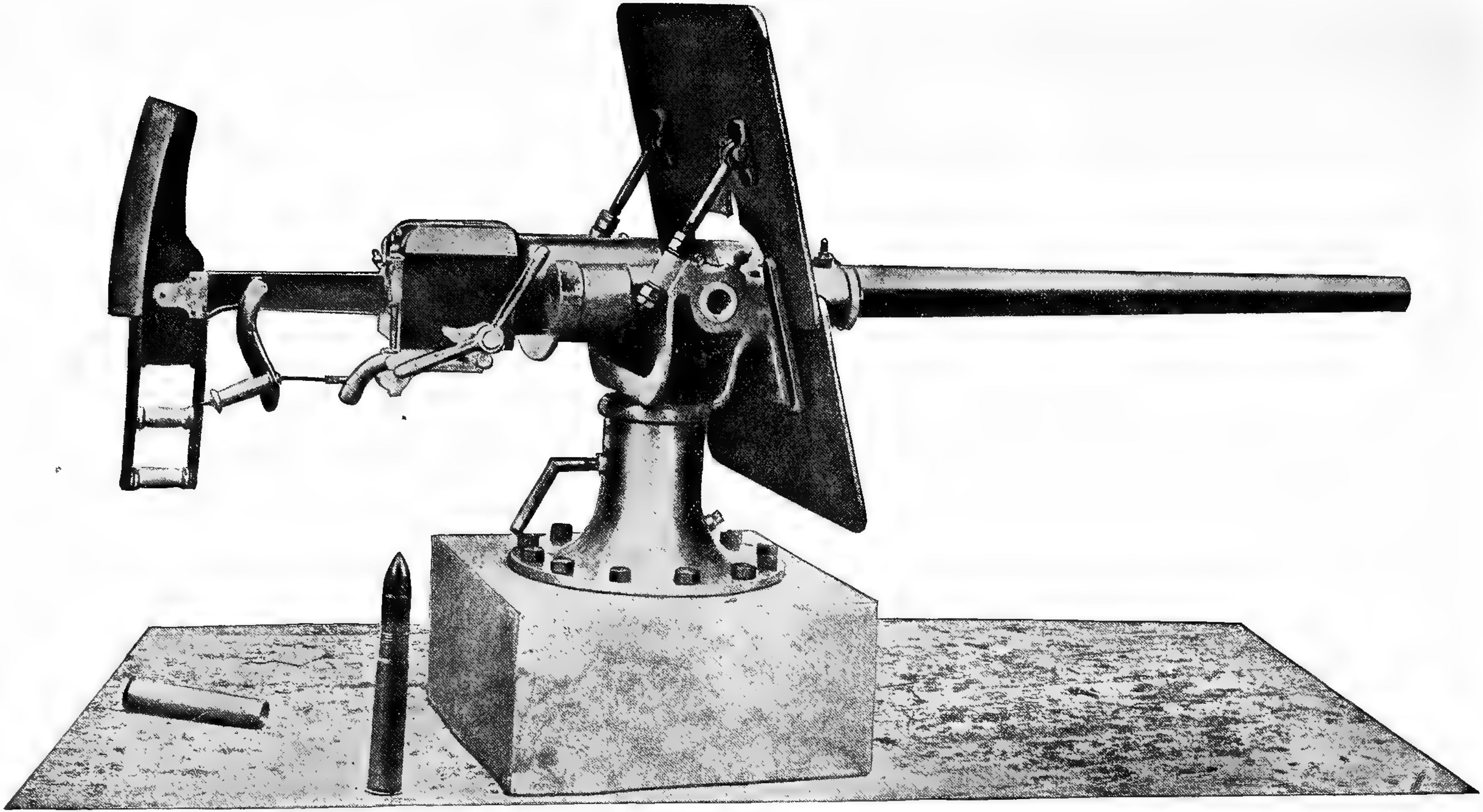


LIGHT 37-MILLIMETER HOTCHKISS RAPID-FIRING GUN ON BOAT CARRIAGE FOR NAVAL SERVICE, OR MOUNTAIN CARRIAGE FOR LAND SERVICE, WITH LIMBER.

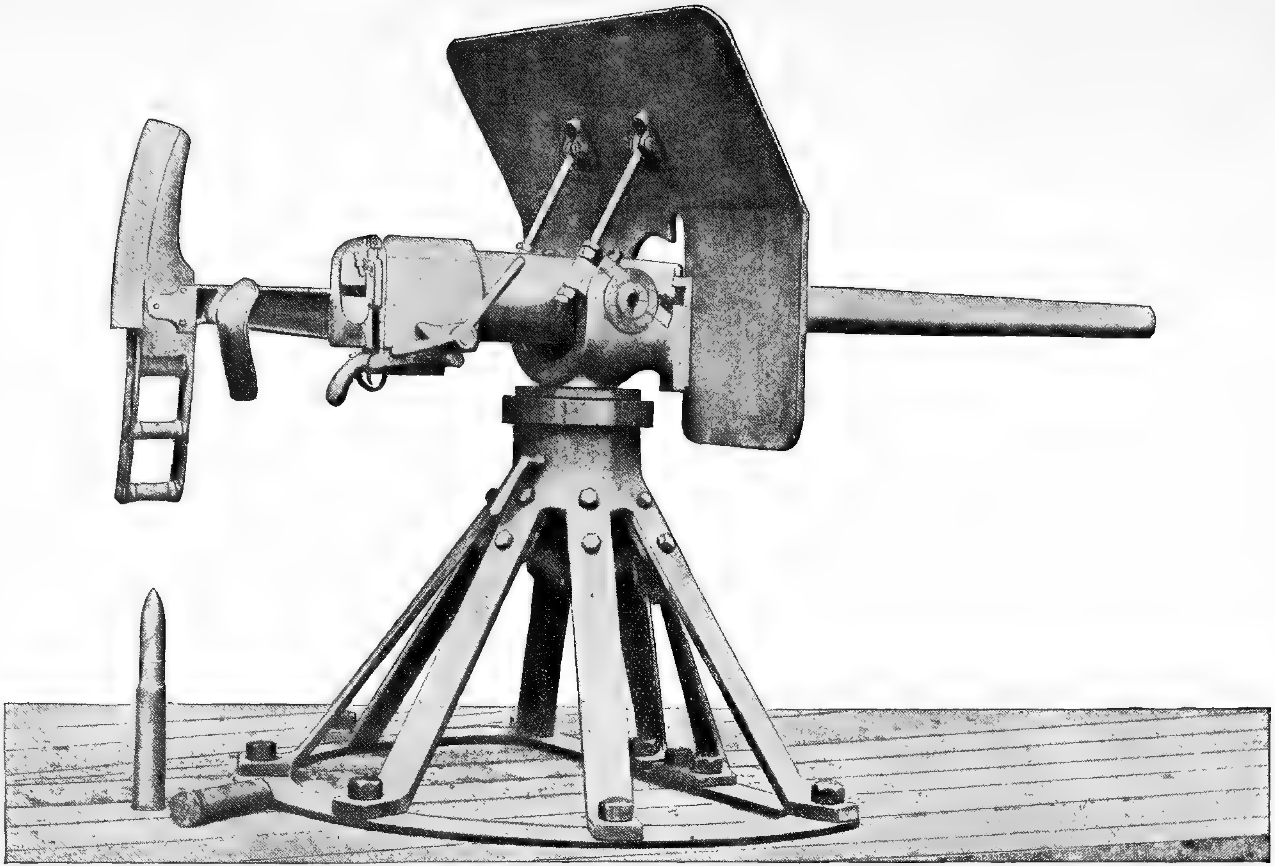
3-POUNDER FIELD CARRIAGE.



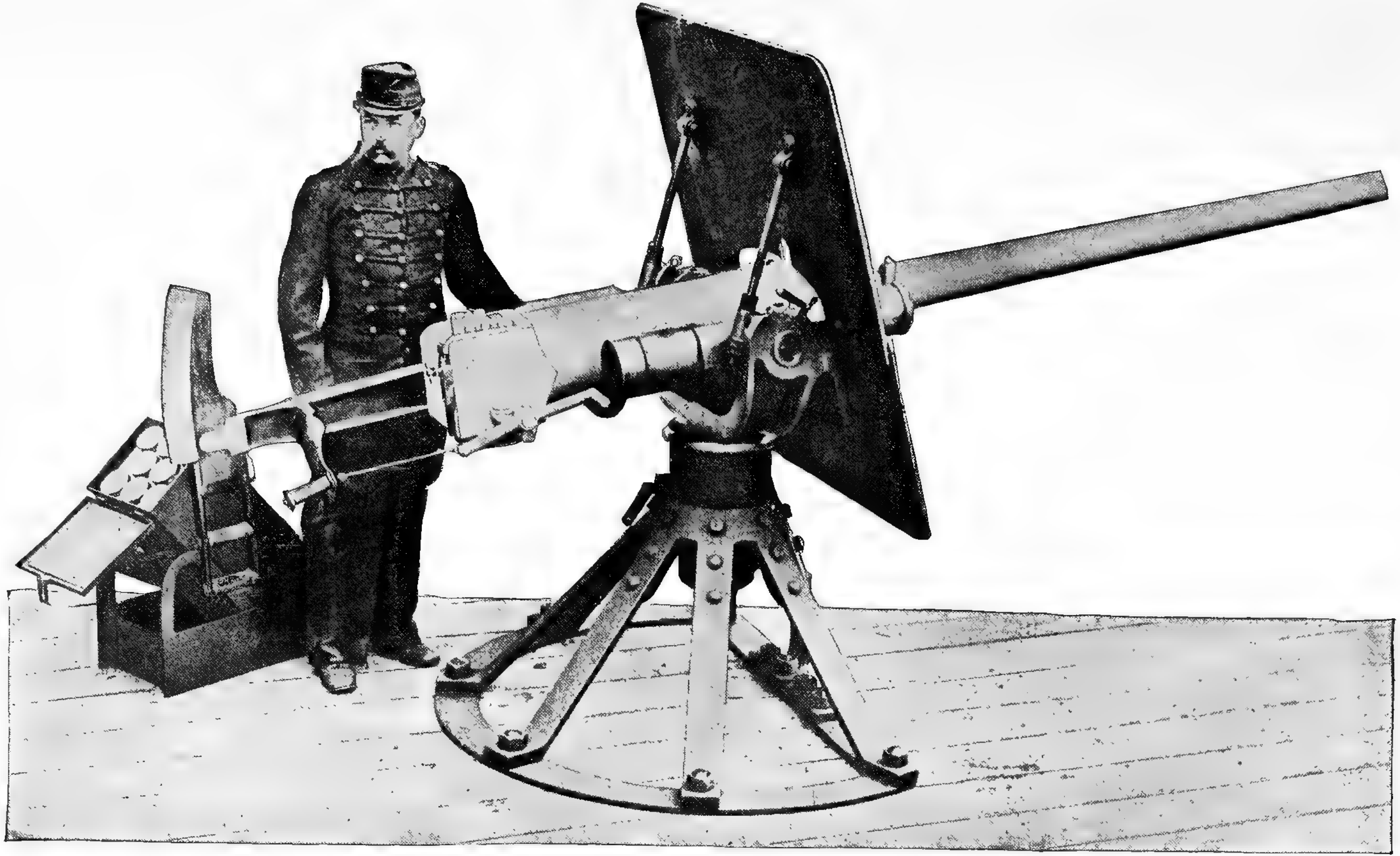
LIGHT 57-MILLIMETER HOTCHKISS RAPID-FIRING GUN ON FIELD CARRIAGE, WITH LIMBER.



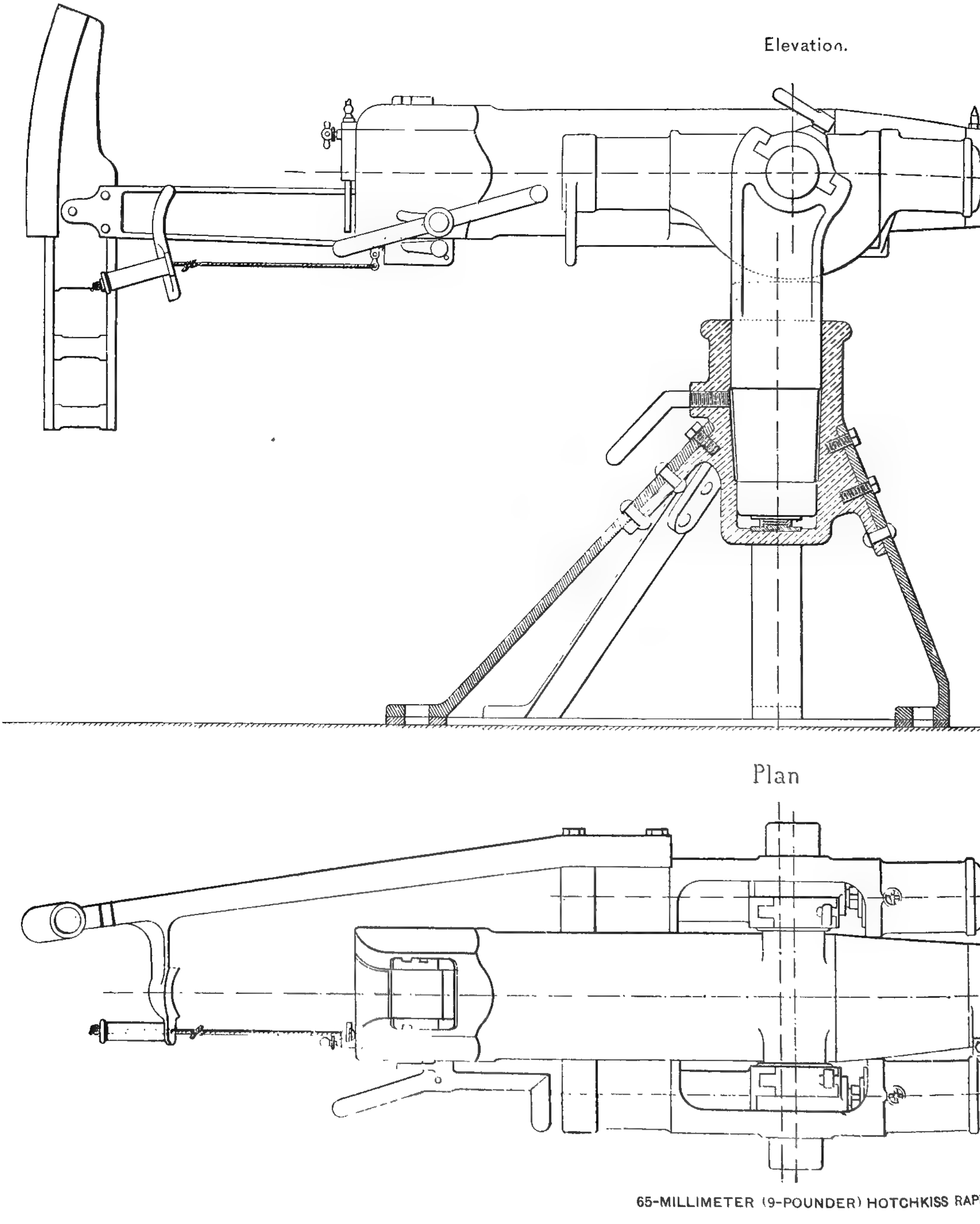
47-MILLIMETER HOTCHKISS RAPID-FIRING GUN ON RECOIL CARRIAGE, WITH SHIELD.



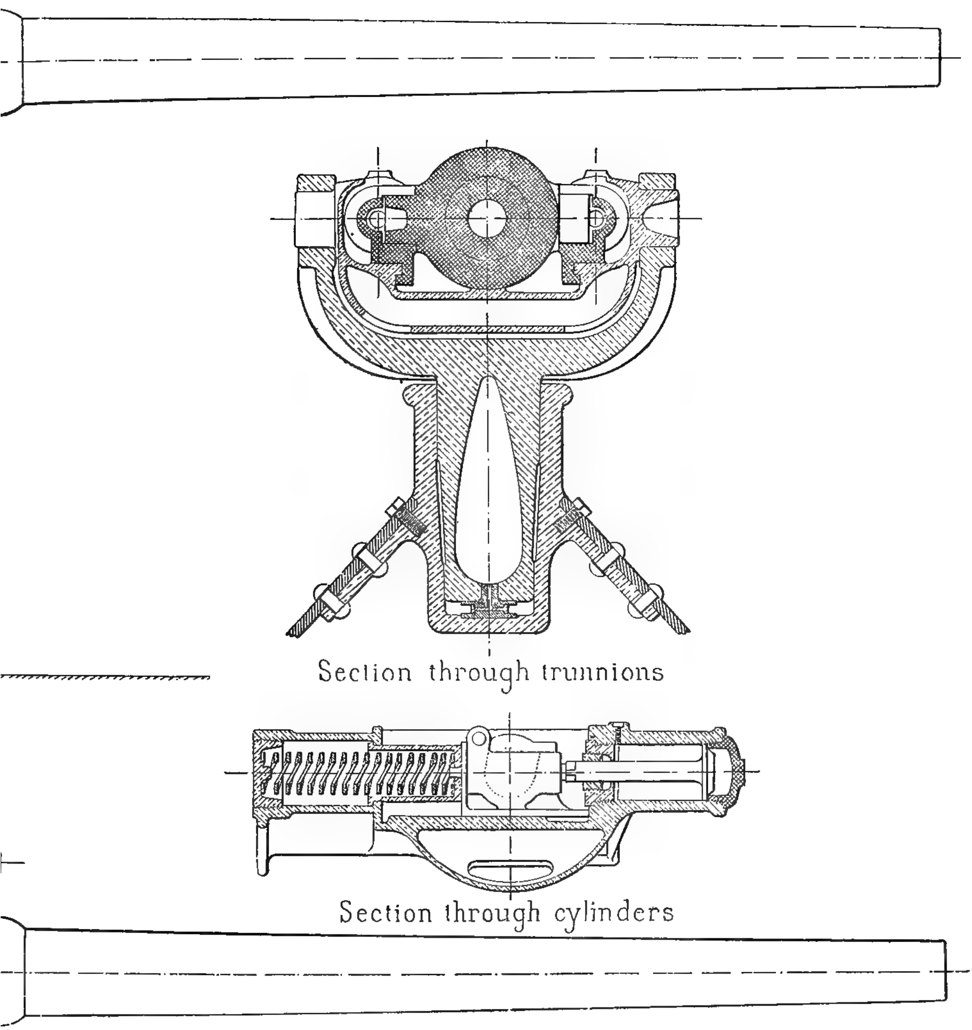
57-MILLIMETER HOTCHKISS RAPID-FIRING GUN ON ELASTIC STAND, WITH SHIELD.



65-MILLIMETER HOTCHKISS RAPID-FIRING GUN ON LIMITED-RECOIL AND AUTOMATIC RETURN CARRIAGE.

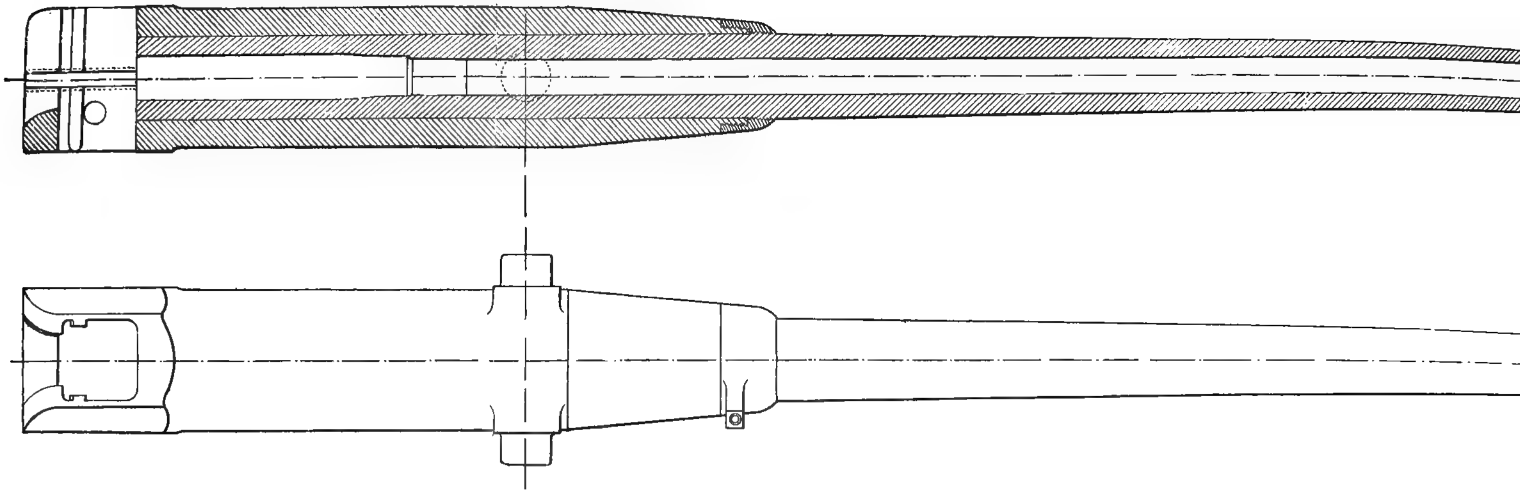


65-MILLIMETER (9-POUNDER) HOTCHKISS RAP

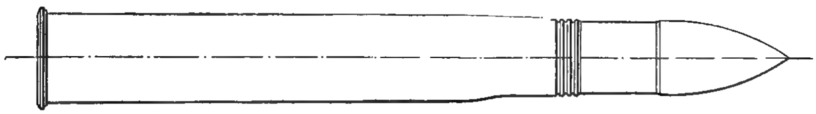


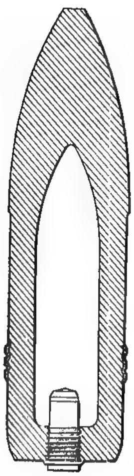
FIRING GUN ON RECOIL MOUNT.

Body of gun

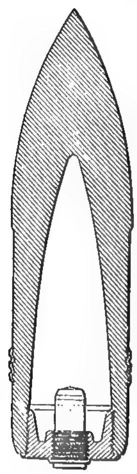


Complete cartridge

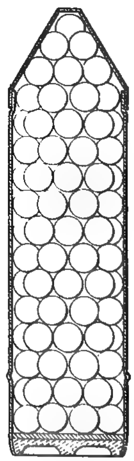




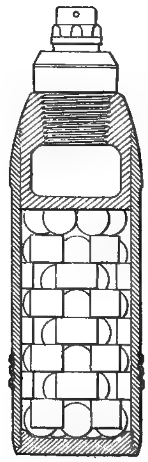
Common shell



Steel shell

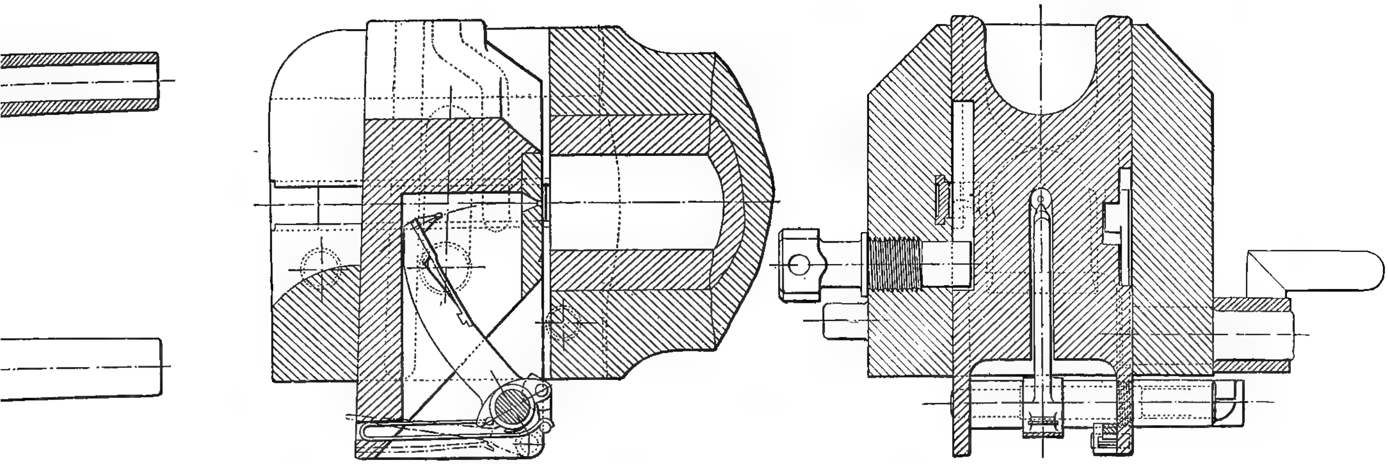


Case shot.

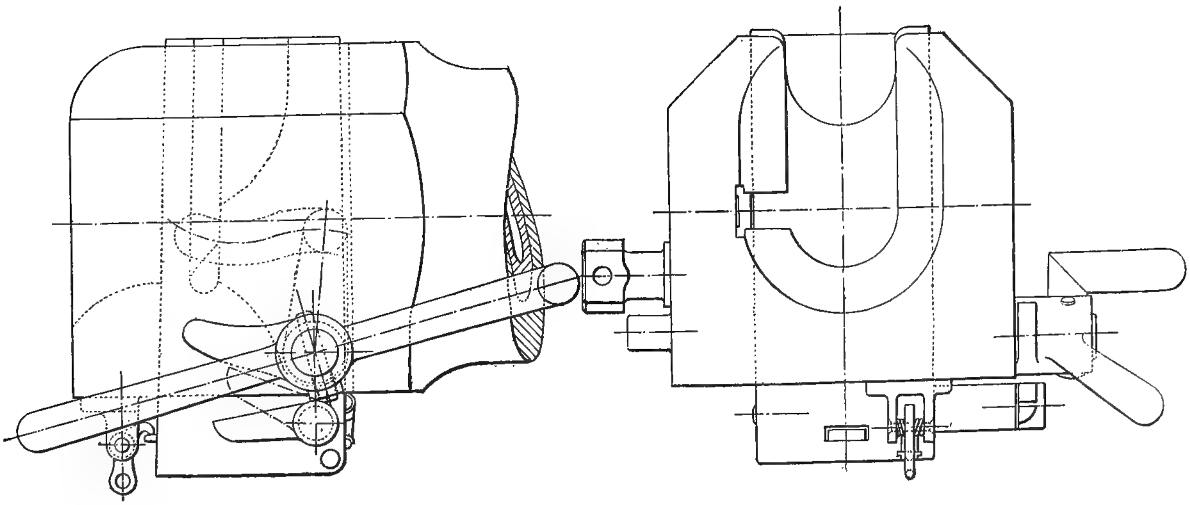


Shrapnel

65-MILLIMETER (9-POUNDER) HOTC

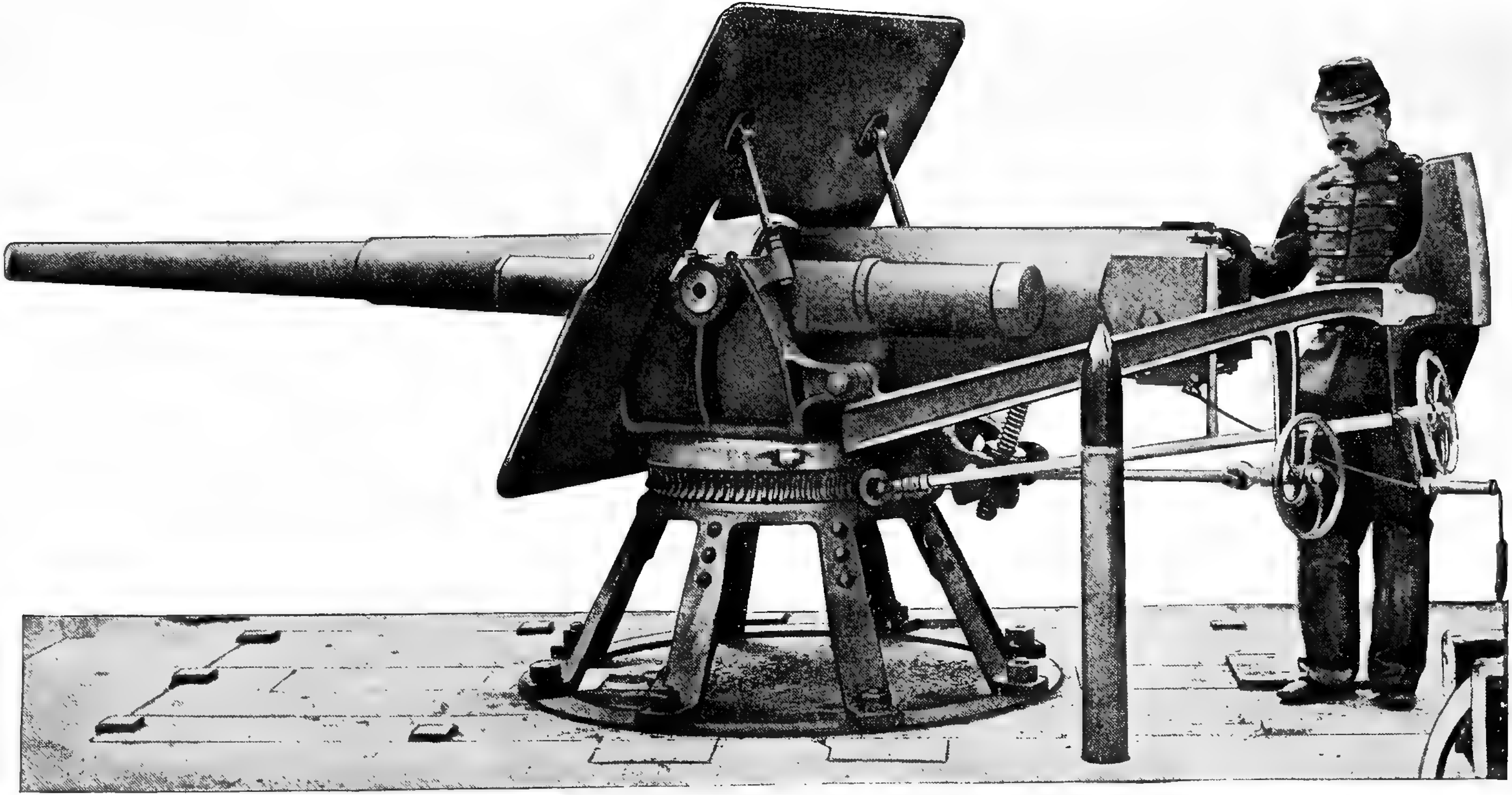


Breech Mechanism.

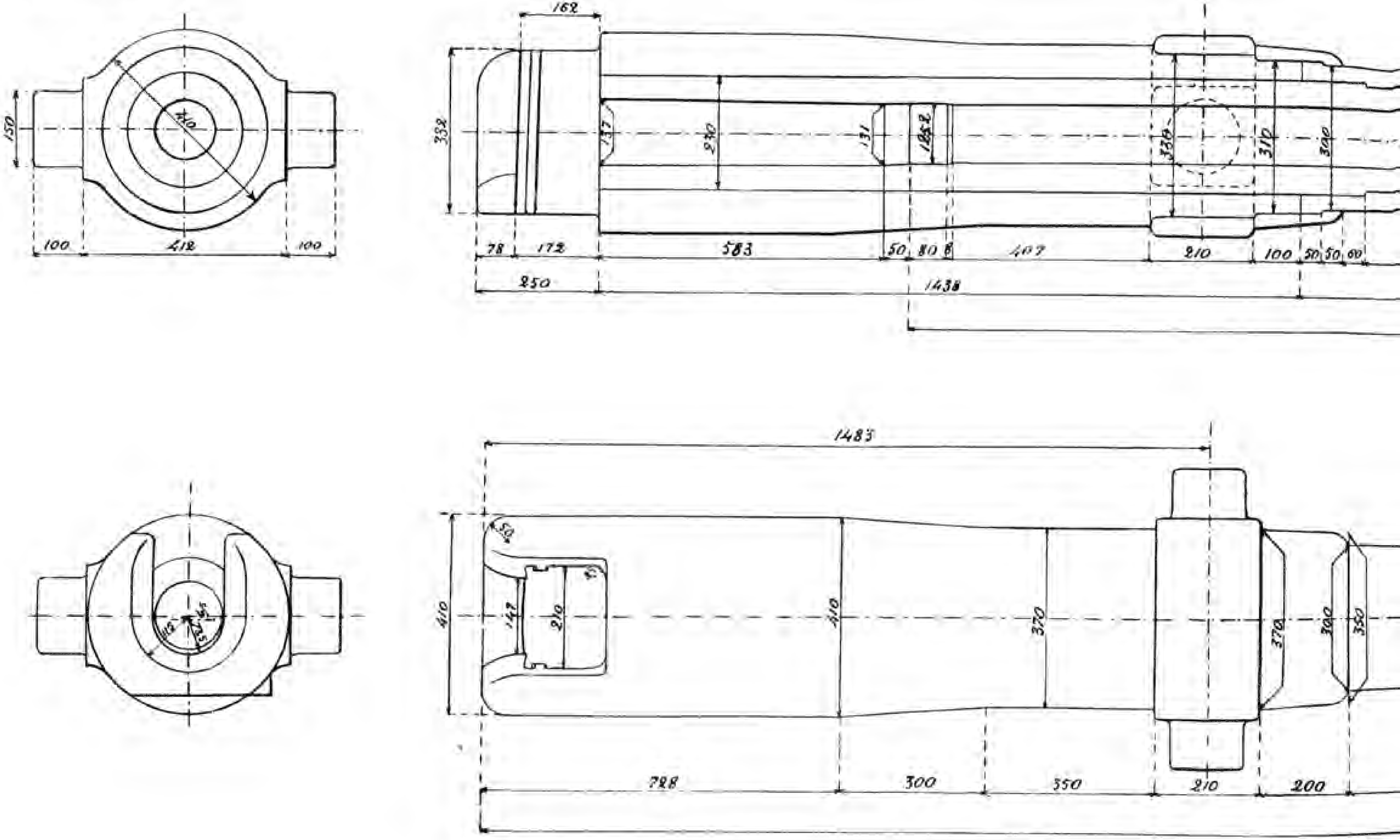


Breech.

HKISS RAPID-FIRING GUN.



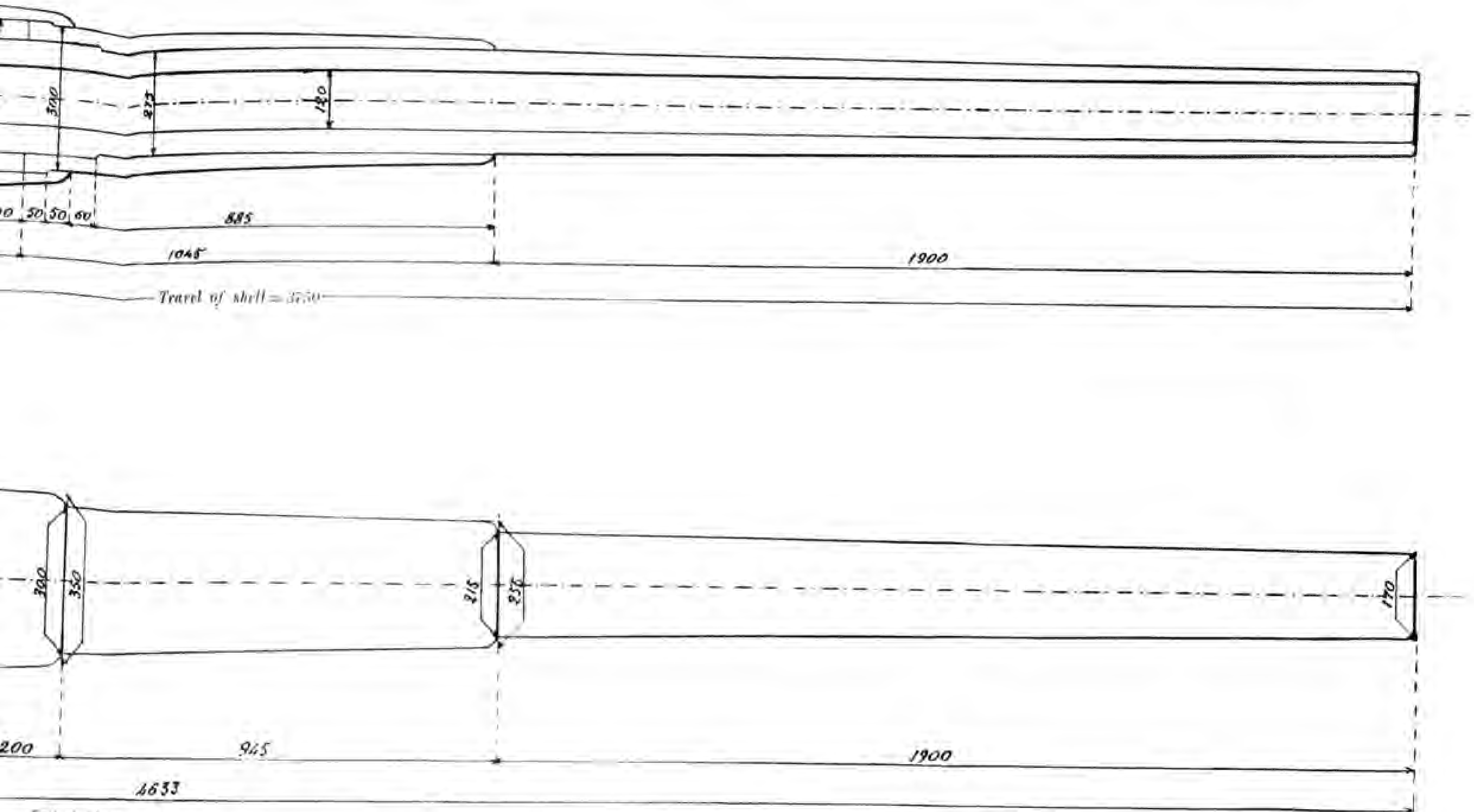
10-CENTIMETER HOTCHKISS RAPID-FIRING GUN ON CENTER-PIVOT, LIMITED RECOIL AND AUTOMATIC RETURN CARRIAGE.



Scale 1/5 natu

12-CENTIMETER HOTCHKIS

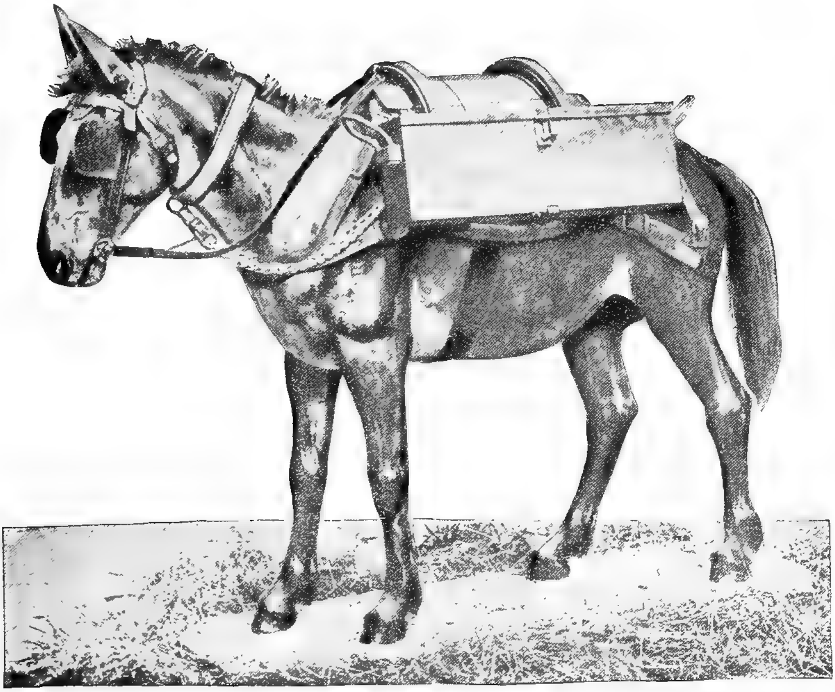
Details of the piece.—Weight, 2,150 kilograms = 4,730 pounds; preponderance, 1



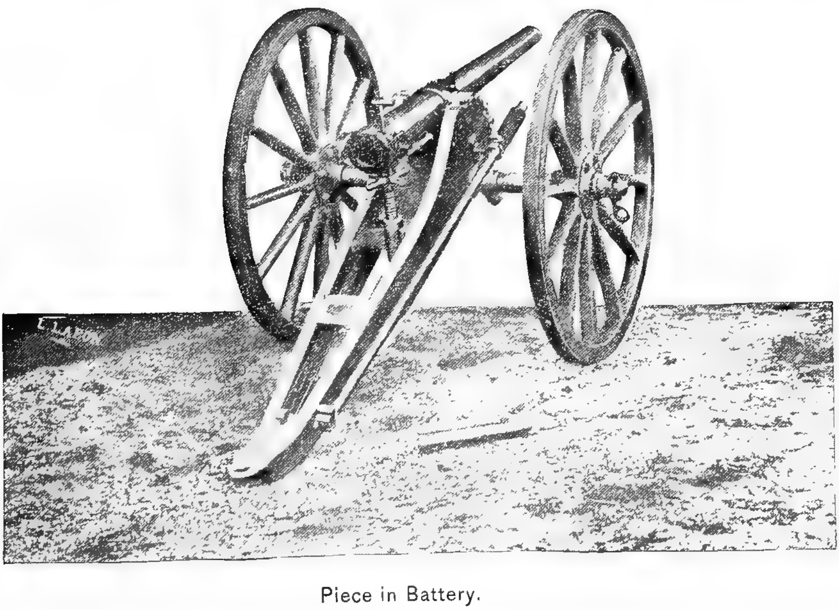
Scale ... nature.

ETER HOTCHKISS RAPID-FIRING GUN

...; preponderance, 10 kilograms – 20 pounds. All dimensions [illegible]

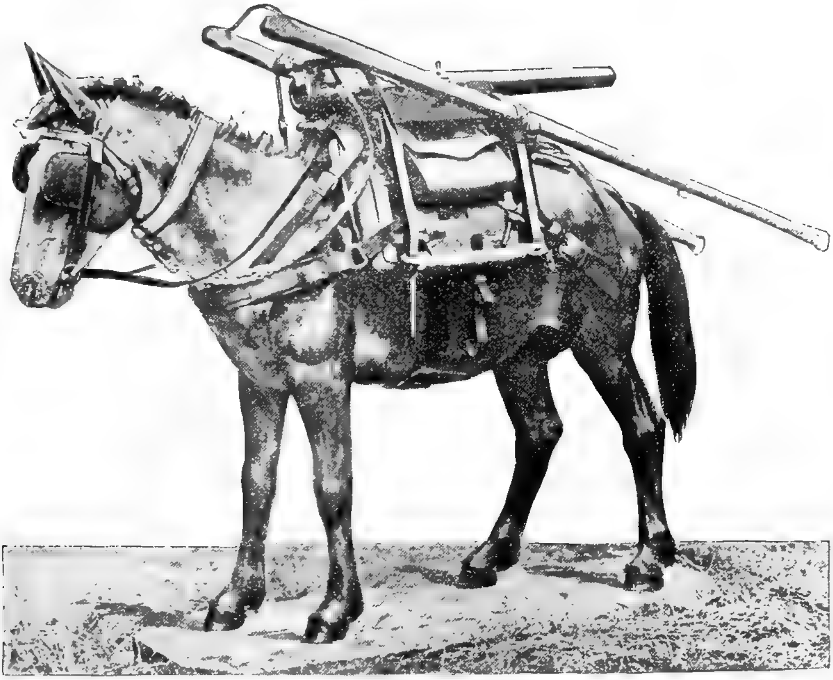


Ammunition Mule.

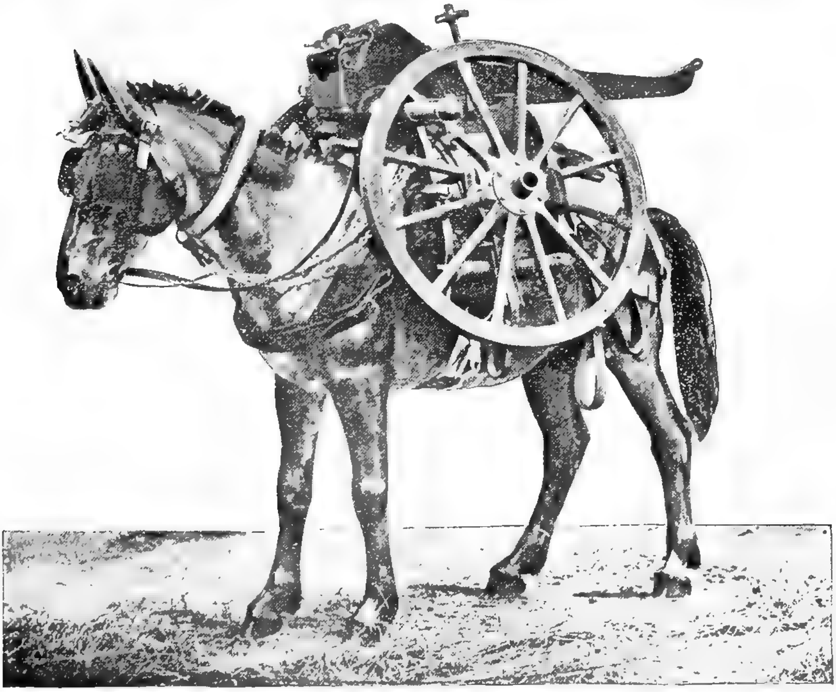


Piece in Battery.

42-MILLIMETER HOTCHKISS MOUNTAIN GUN AND CARRIAGE.

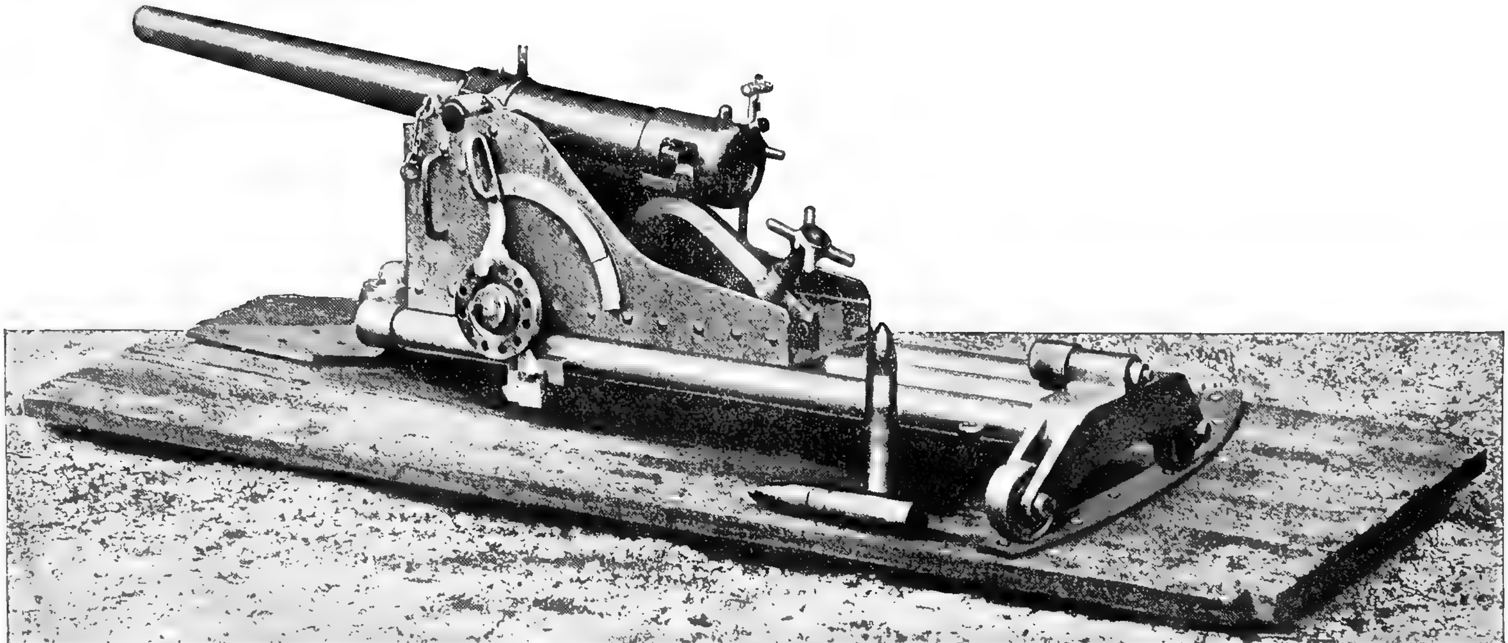


Gun Mule.

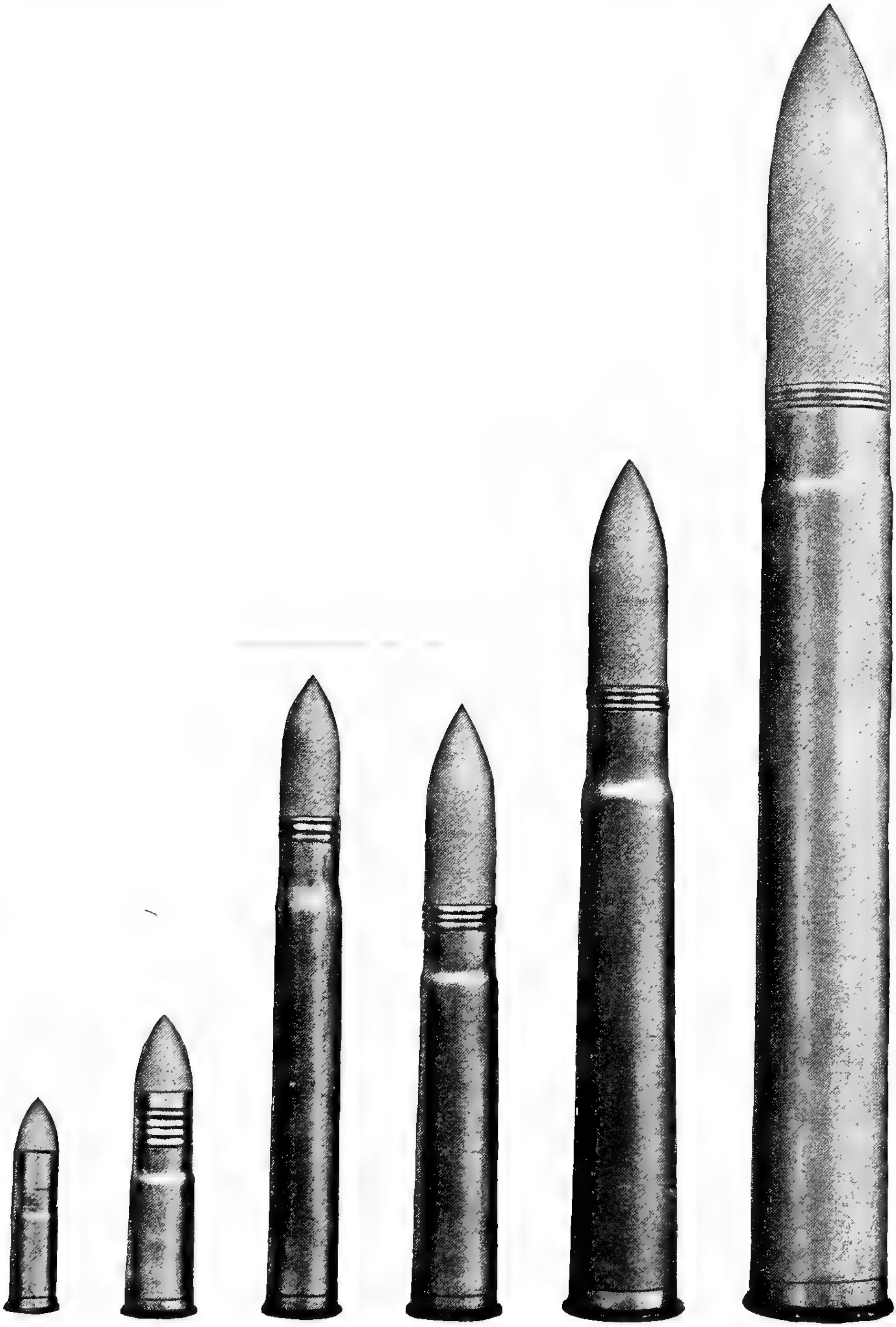


Carriage Mule.

42-MILLIMETER HOTCHKISS MOUNTAIN GUN AND CARRIAGE PACKED FOR TRANSPORTATION.



42-MILLIMETER HOTCHKISS YACHT GUN AND CARRIAGE.



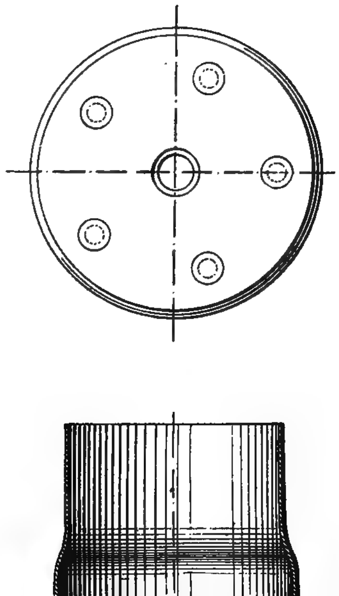
1 2 3 4 5 6

CARTRIDGES.

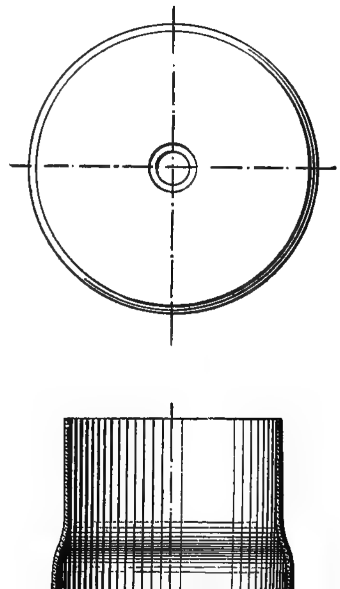
1. 37^{mm} = 1 pounder; 2. 47^{mm} = 2½ pounder; 3. 47^{mm} = 3 pounder; 4. 57^{mm} = 6 pounder; 5. 65^{mm} = 9 pounder; 6. 10^{cm} = 33 pounder.

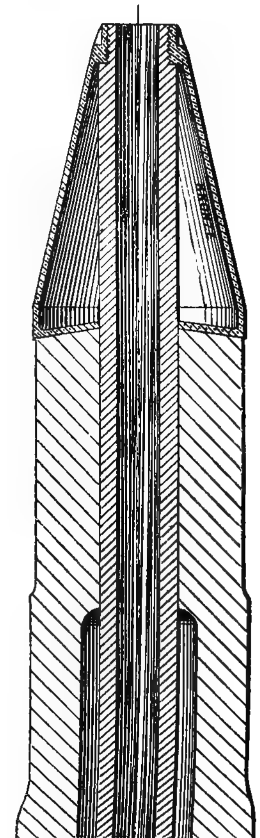
Drill Cartridge.

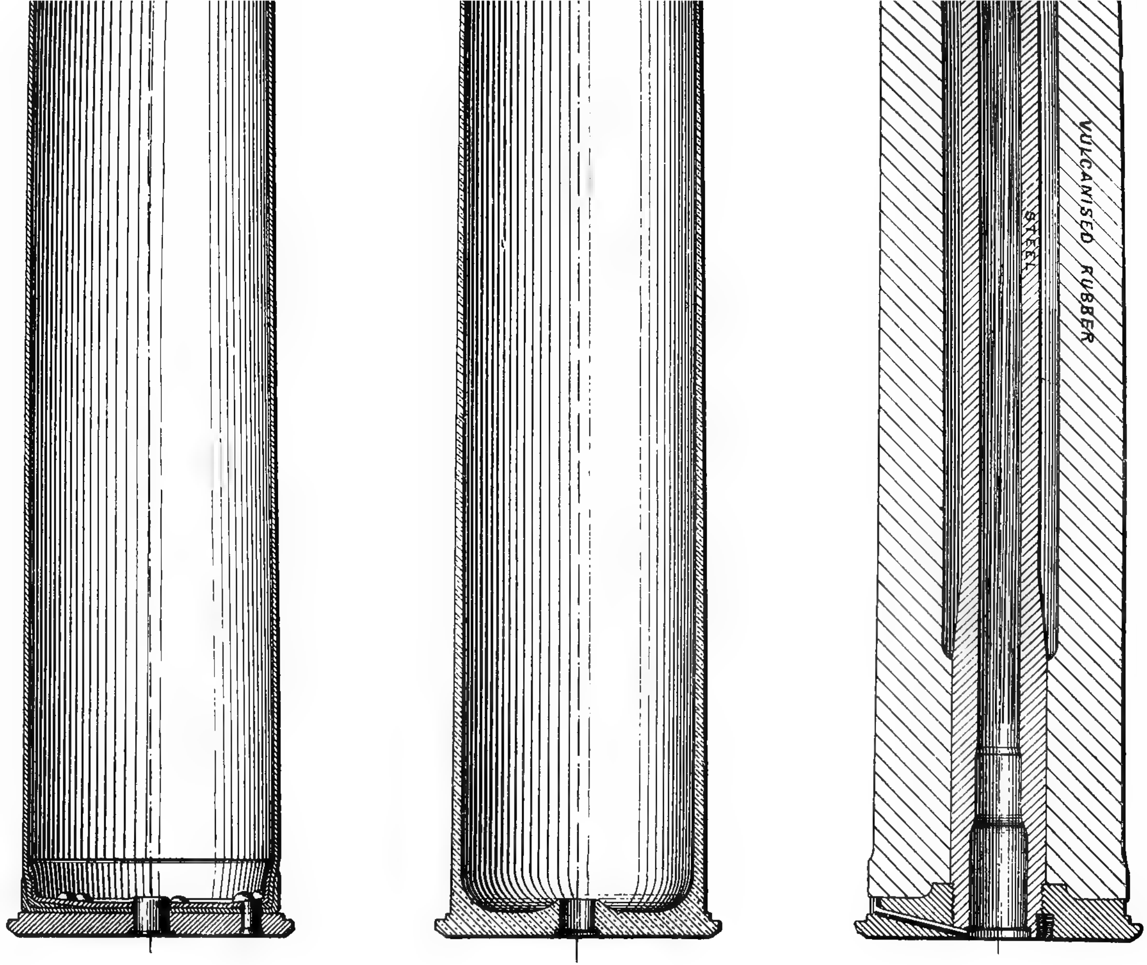
Built up Case



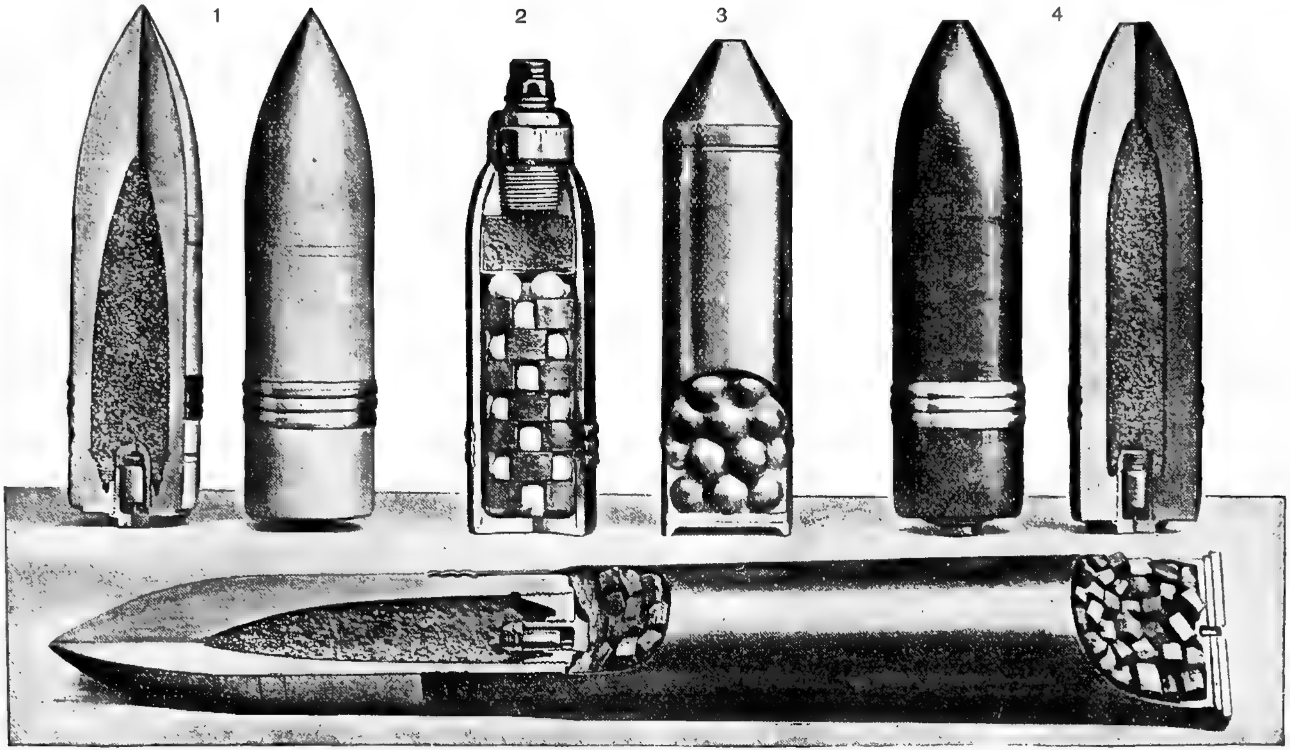
Solid drawn Case.







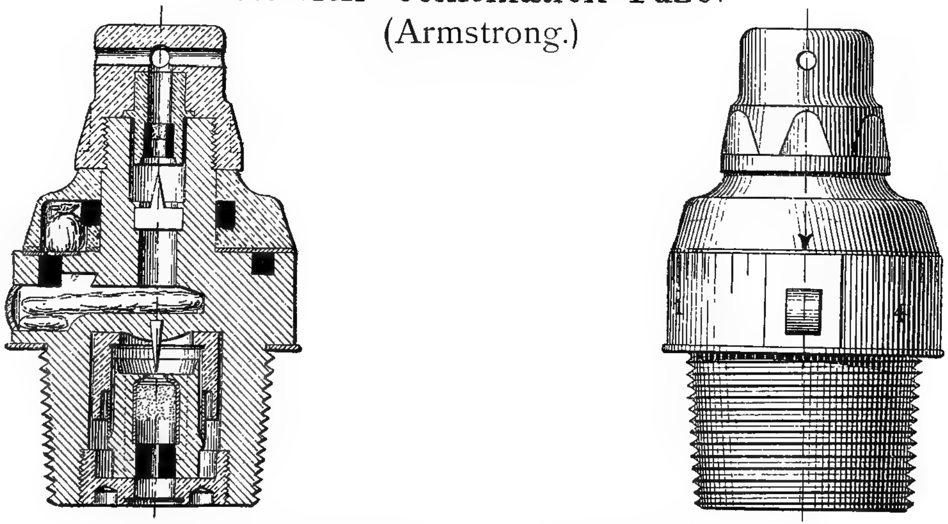
CARTRIDGE CASES.



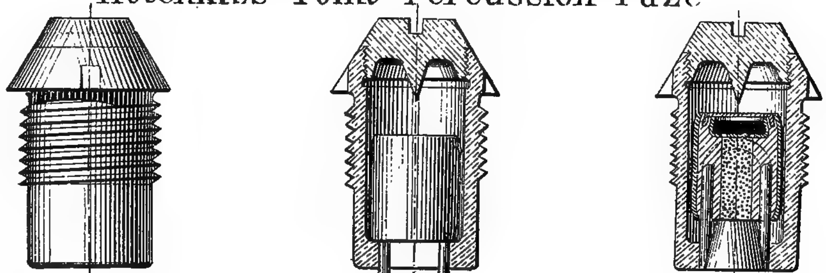
AMMUNITION IN SECTION.

1. Steel shell. 2. Shrapnel. 3. Case shot. 4. Common shell. 5. Complete cartridge.

Elswick Combination Fuze.
(Armstrong.)



Hotchkiss Point Percussion Fuze

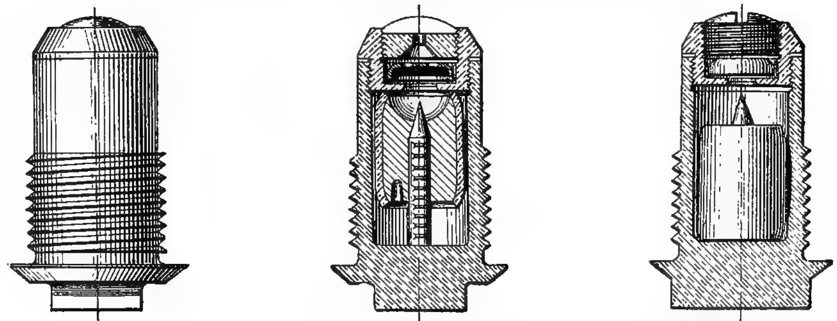


Position of plunger

Position of plunger
during flight

before firing

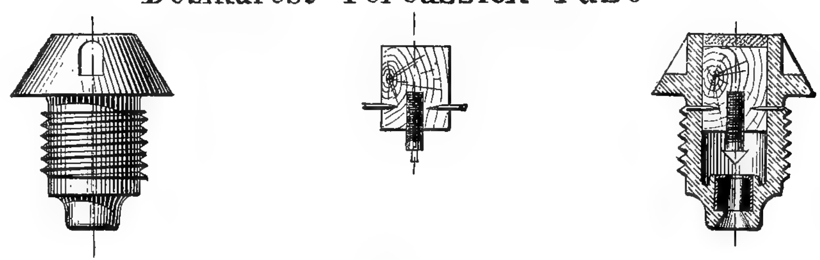
Hotchkiss Base Percussion Fuze.



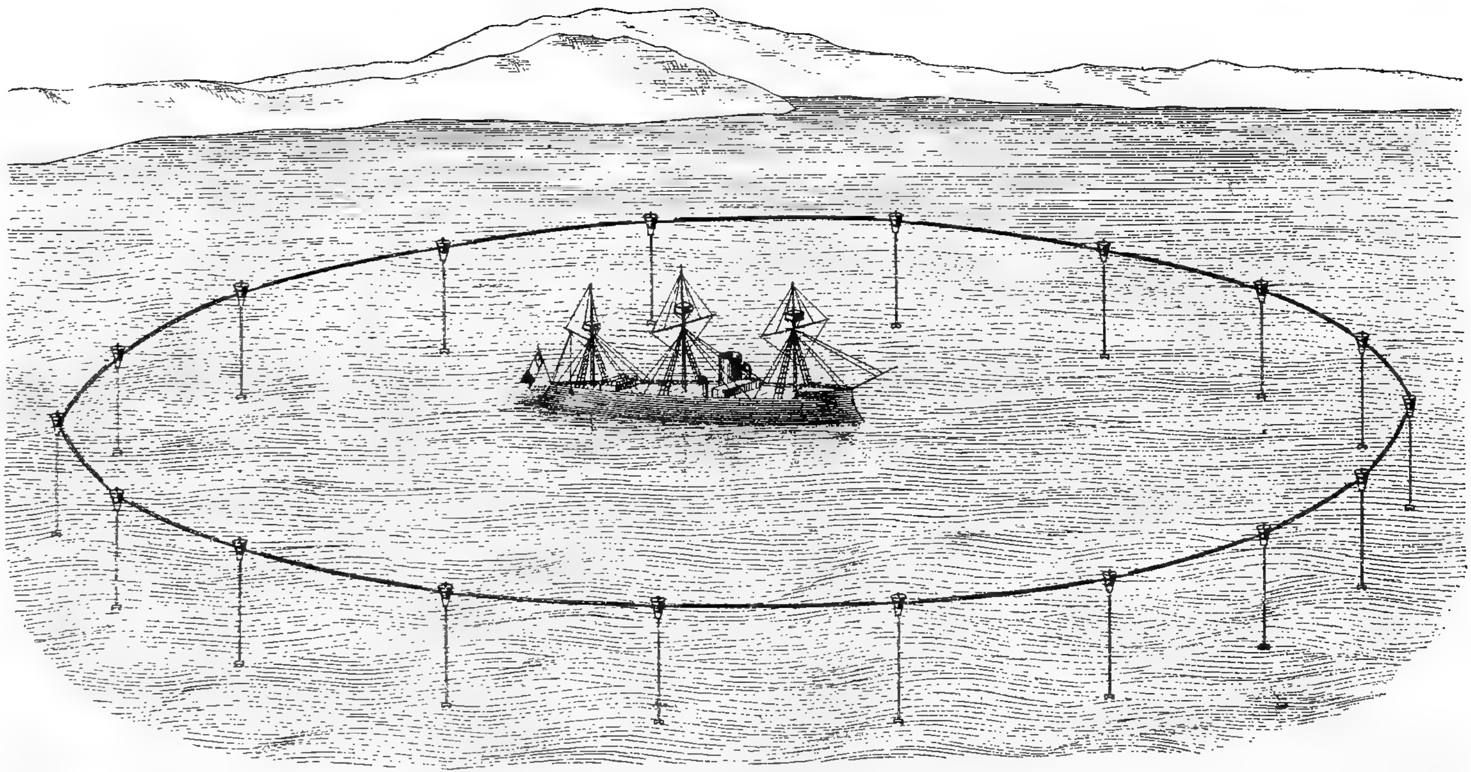
Position of plunger
before firing

Position of plunger
during flight

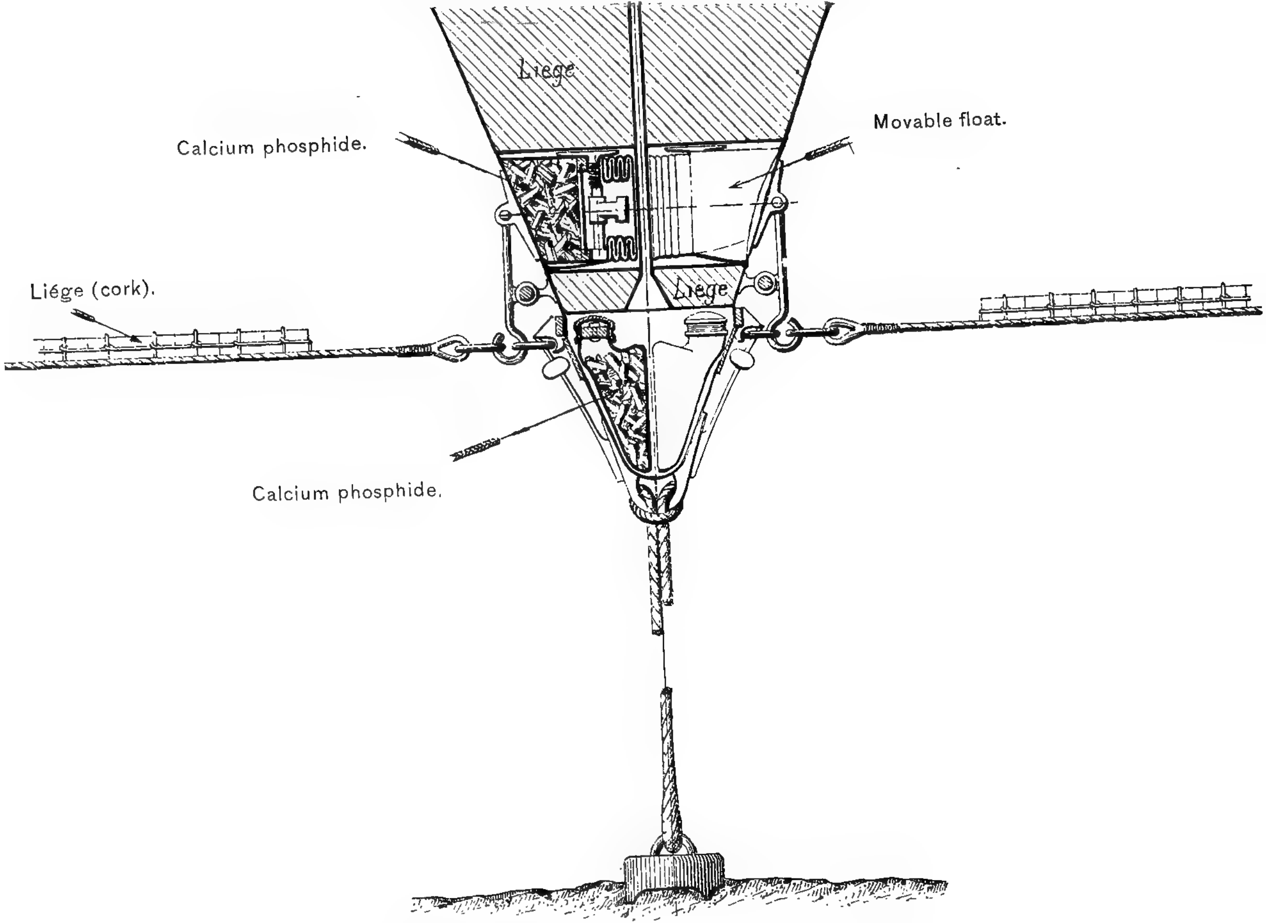
Desmarest Percussion Fuze



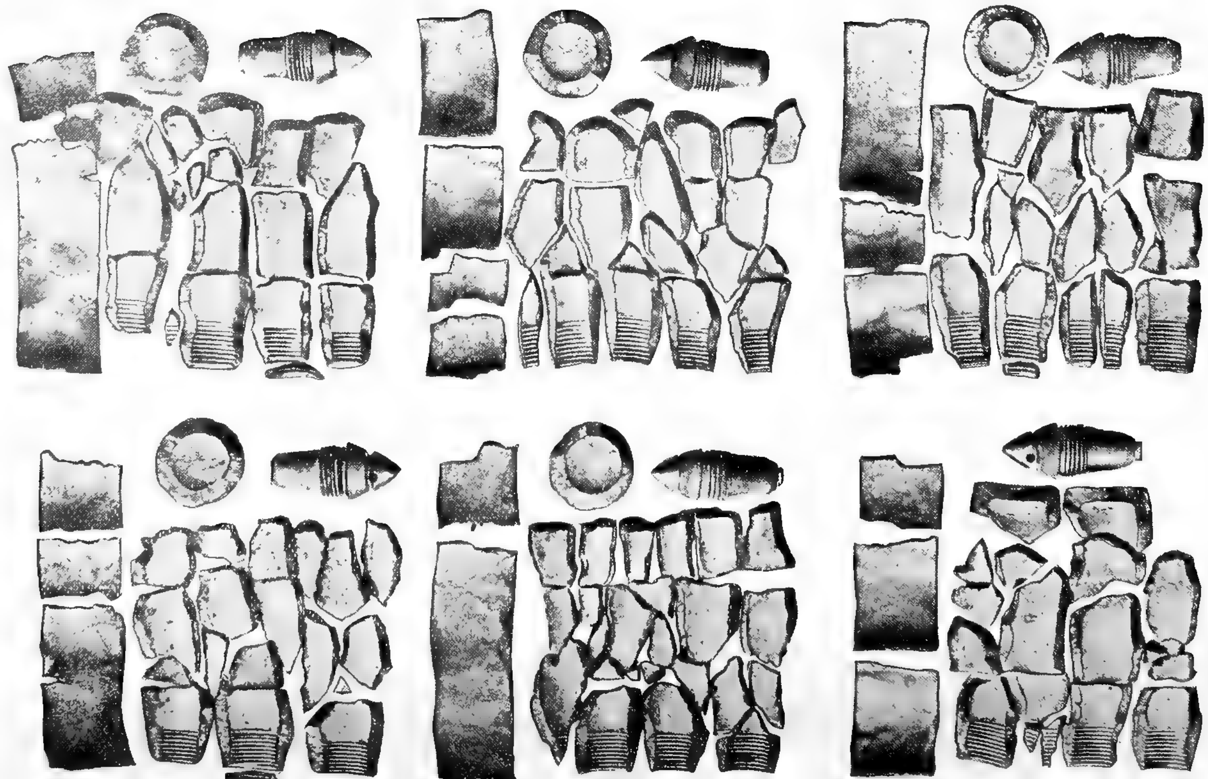
FUZES

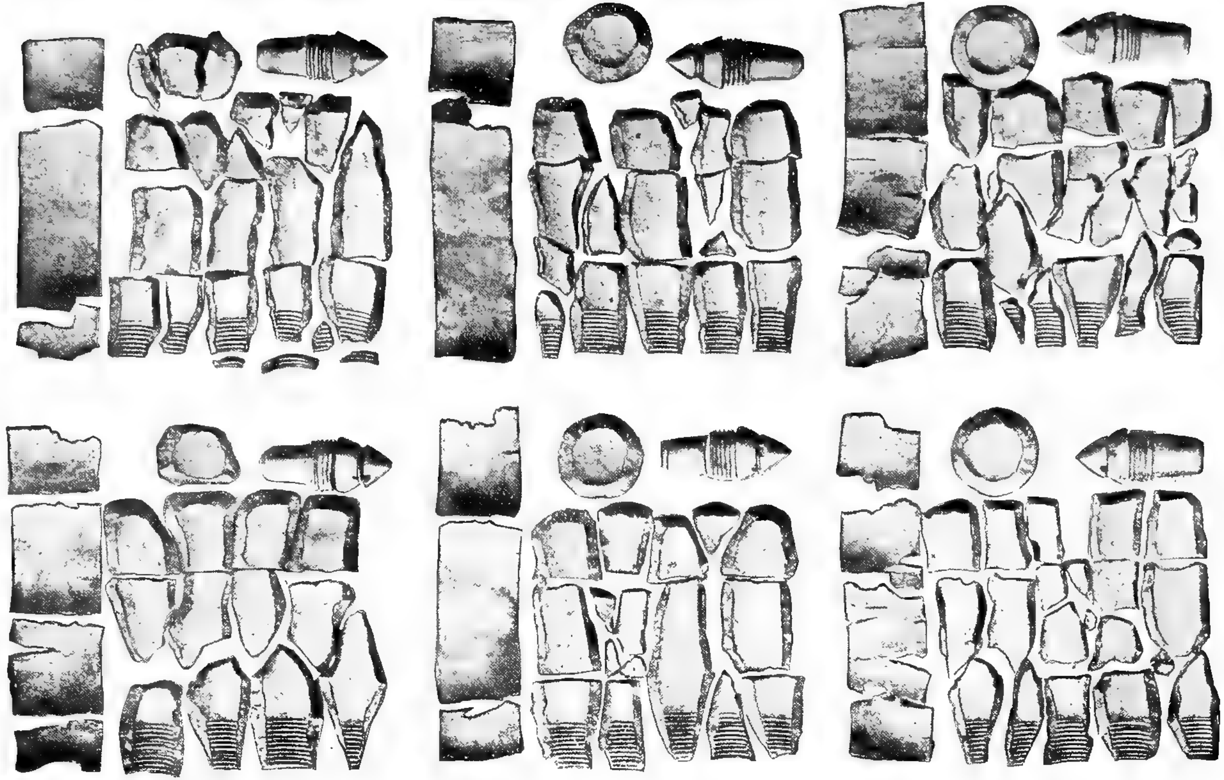


BUOY.



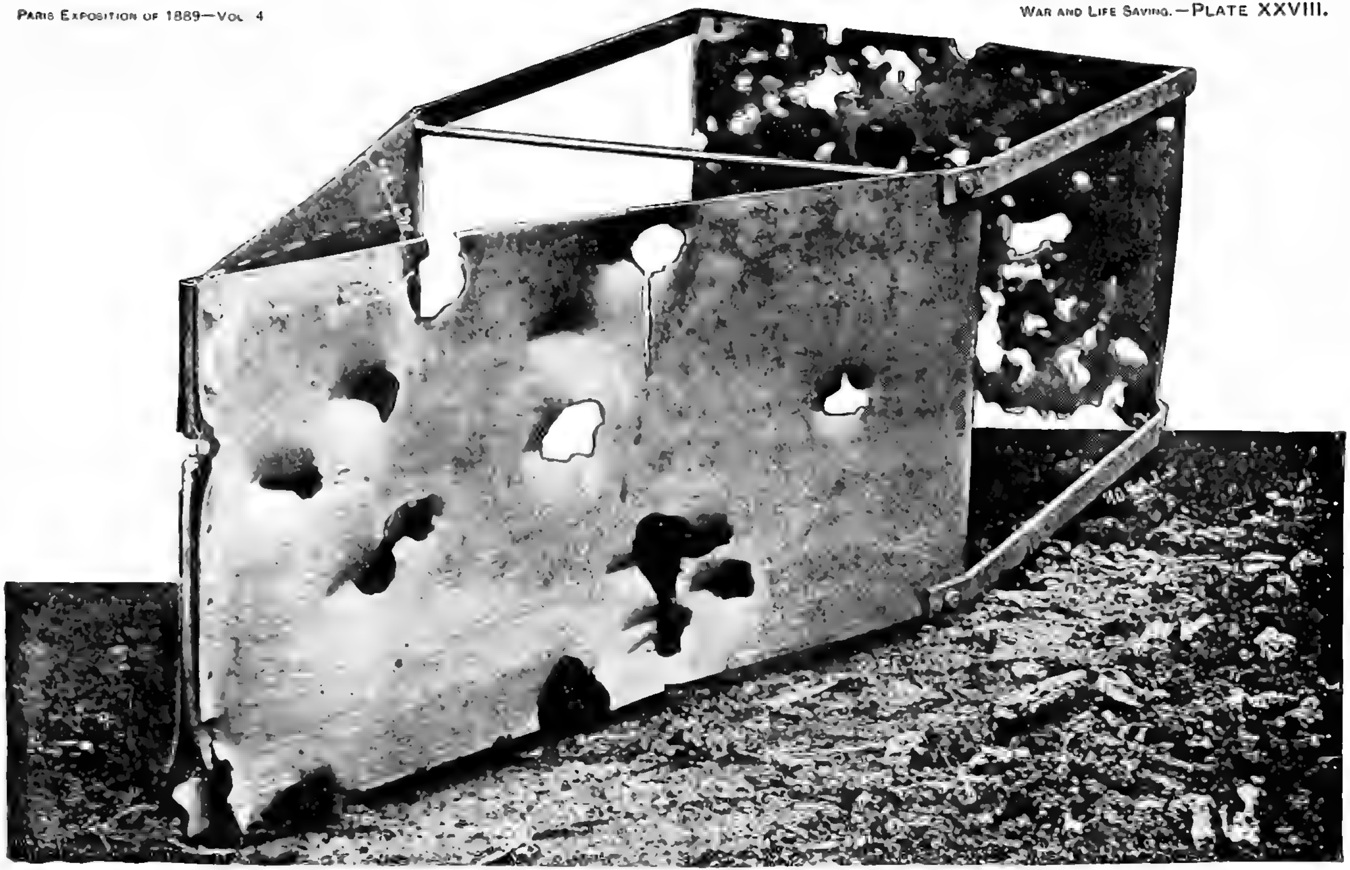
WARNING TORPEDO GUARD, FOR THE PROTECTION OF VESSELS OF WAR.





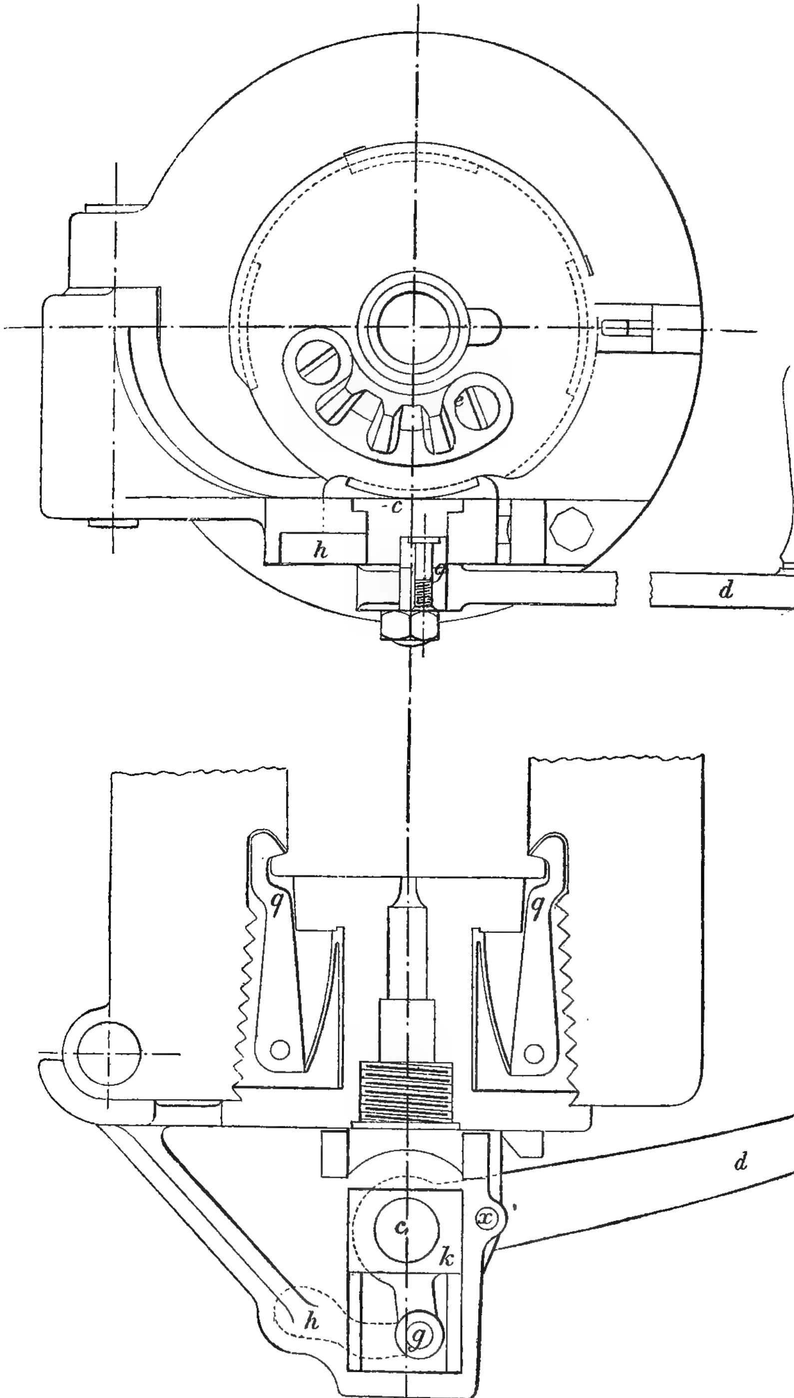
BURST PROJECTILES OF HOTCHKISS REVOLVING CANNON.

Caliber 37^{mm} ; weight, 550 grams. Bursting charge, 25 grams. 12 shells, 308 fragments.

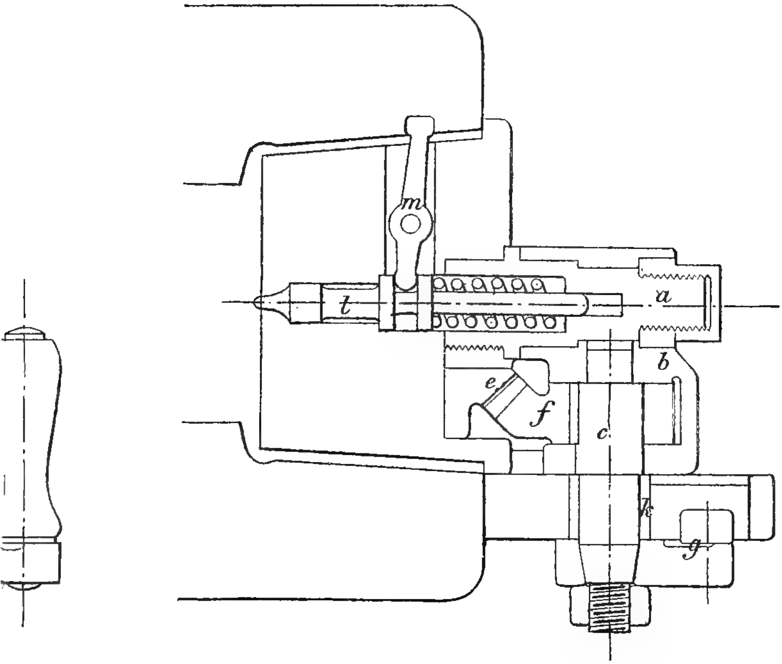


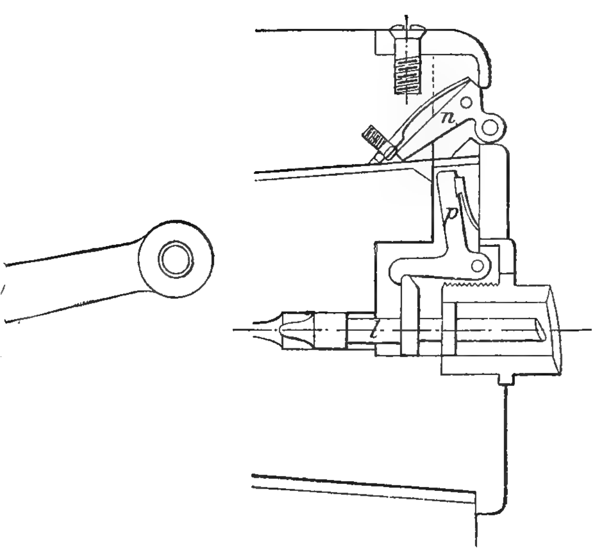
TARGET REPRESENTING THE BOW AND FIRST BULKHEAD OF H. M. TORPEDO BOAT "LIGHTNING", PERFORATED BY COMMON SHELL OF HOTCHKISS REVOLVING CANNON, 37^{mm} CALIBER, NAVAL PATTERN.

Direction of fire parallel to line of keel. Striking velocity, 330^{m}. Corresponding to 230 range.

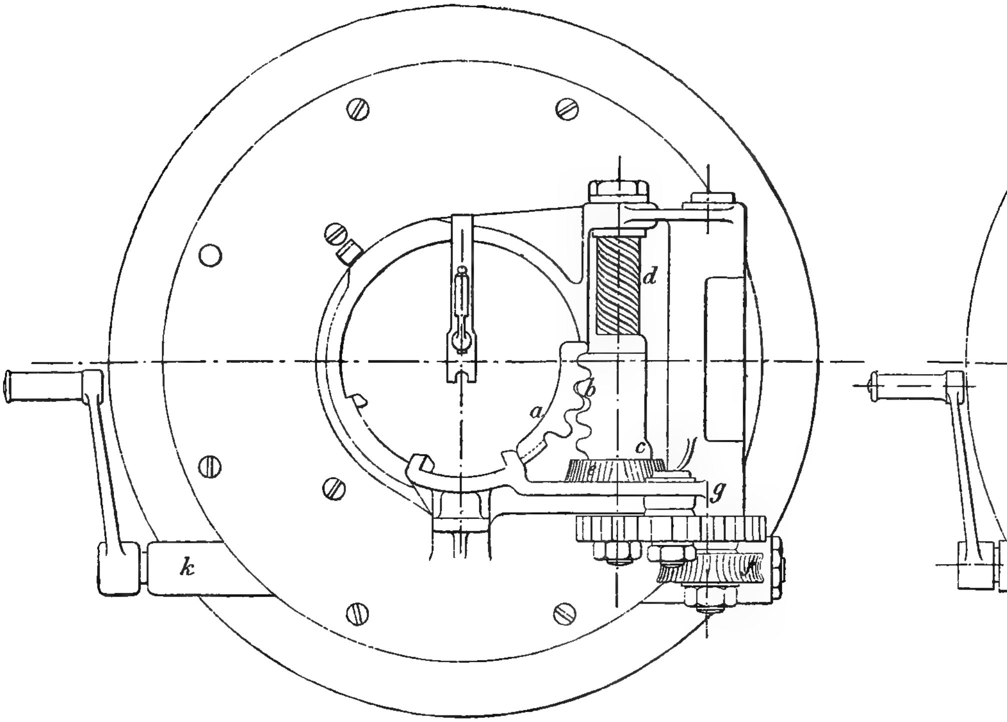


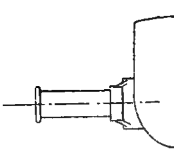
CANET'S FERMETURE FOR





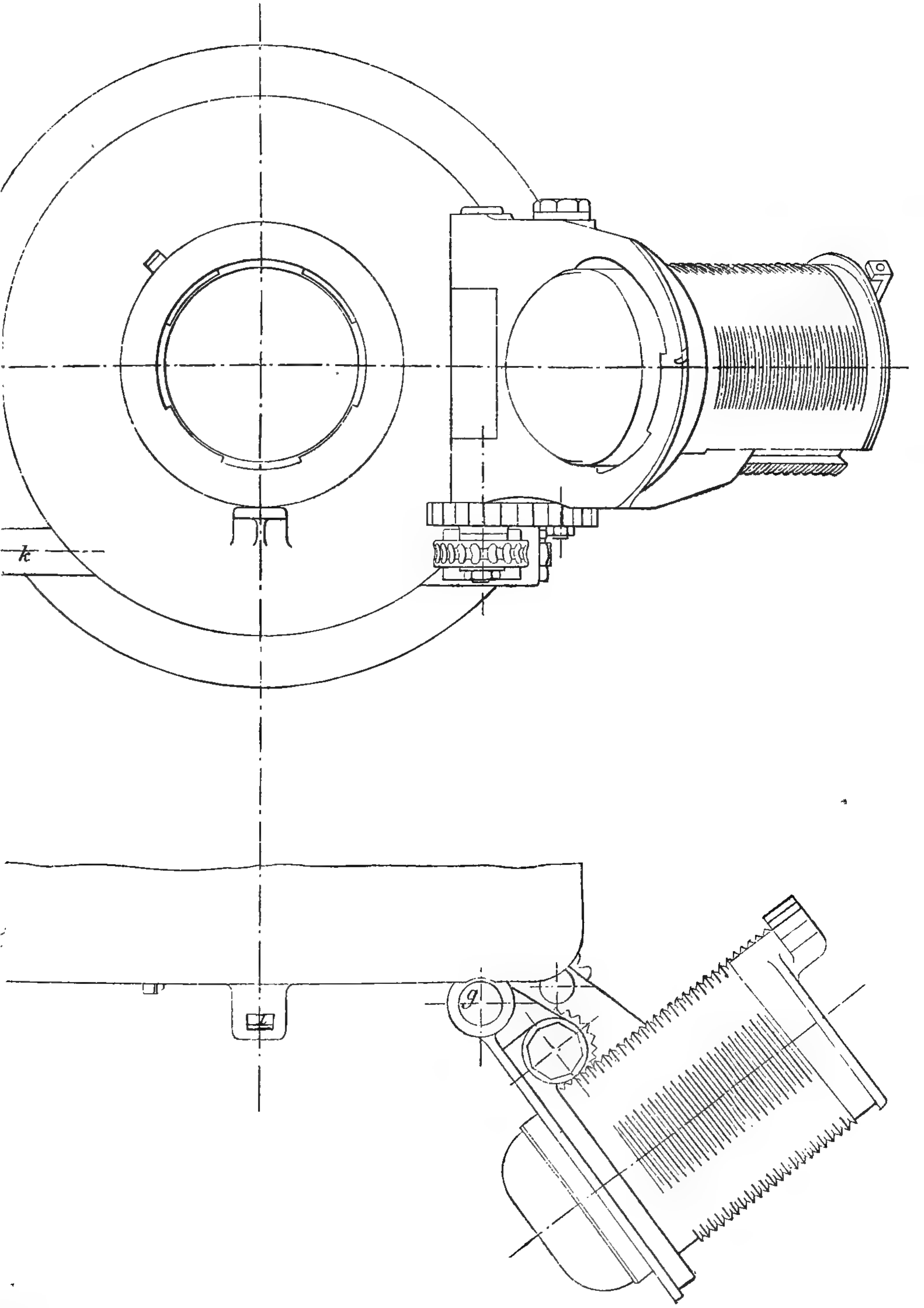
, RAPID-FIRING GUNS.



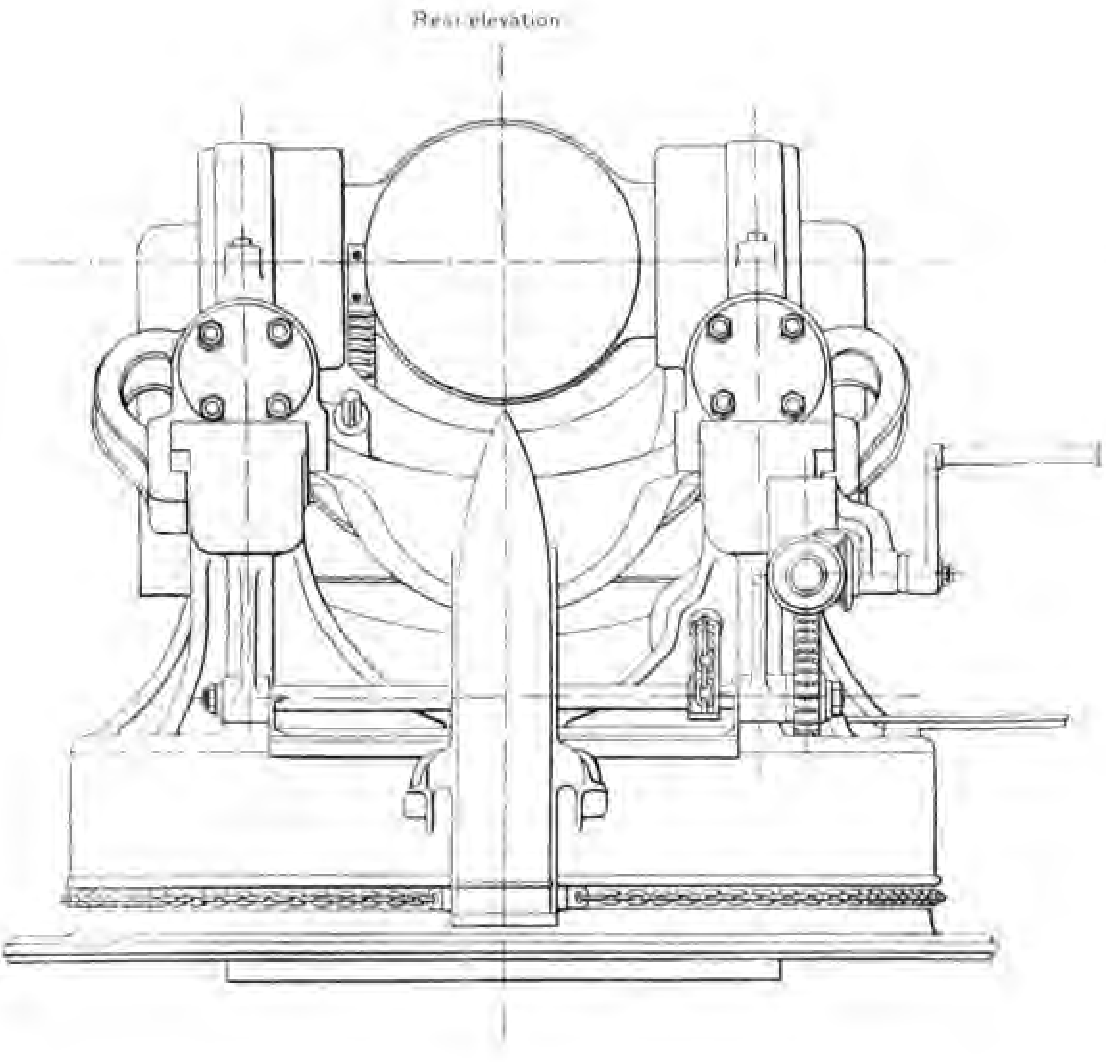


CANET'S SYSTEM OF BREECH

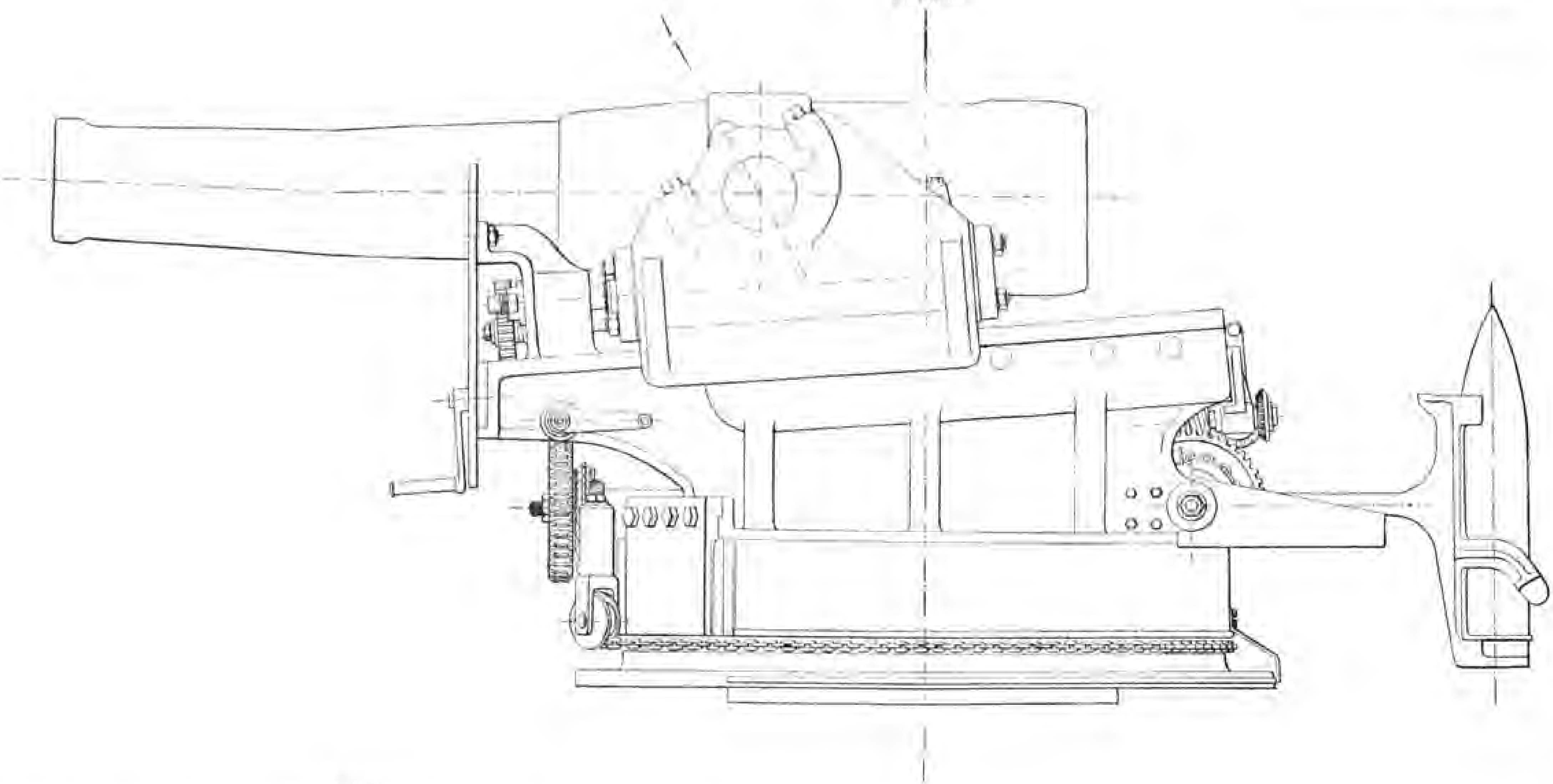
Designed to be operate



ERMETURE FOR HEAVY GUNS.
by mechanical means.

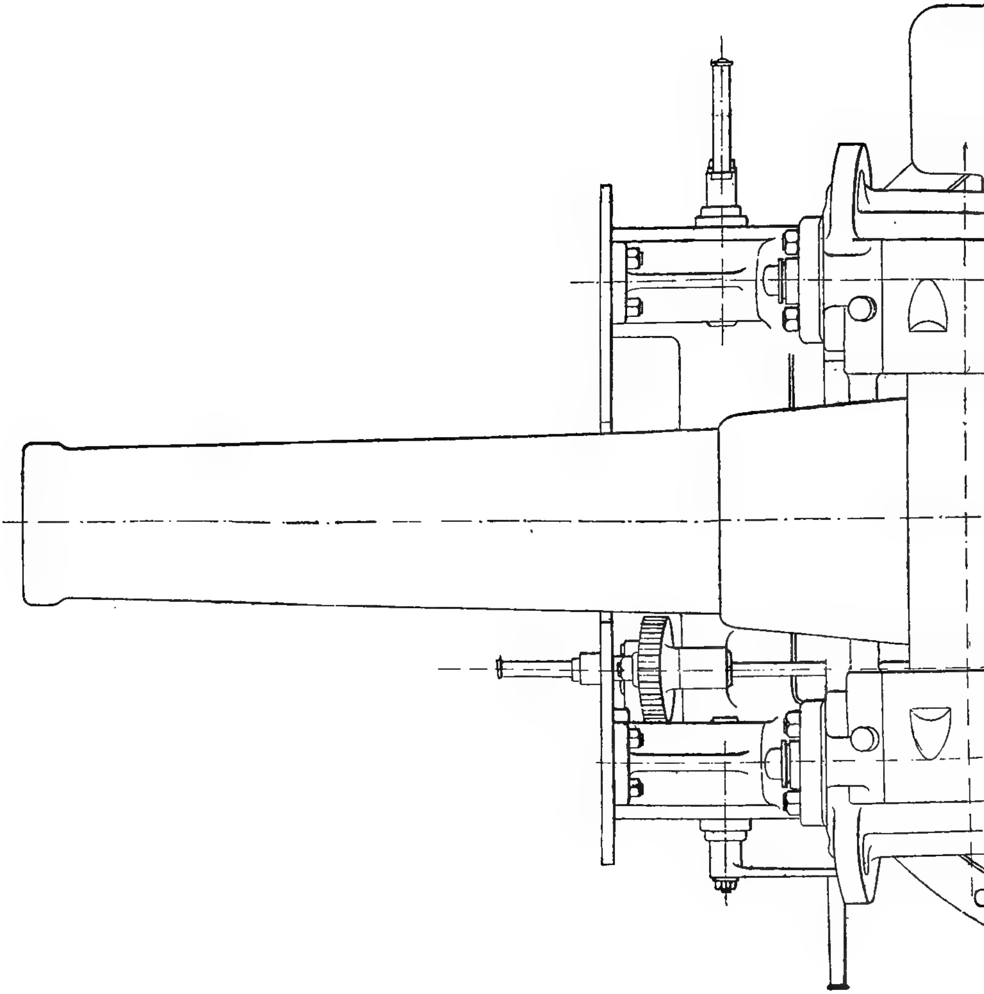


27 CENTIMETER CANET HOWITZER ON A CENTE



Scale

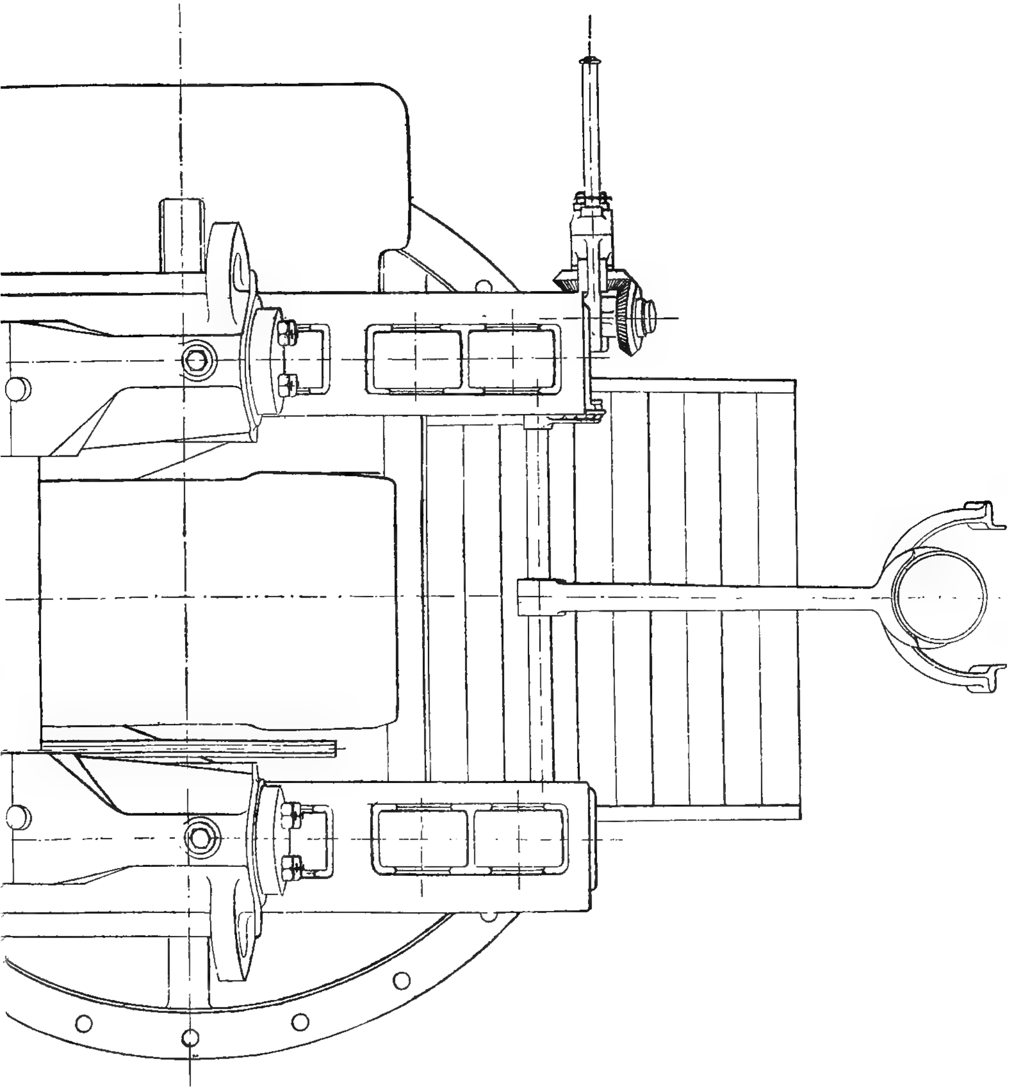
TIMETER CANET HOWITZER ON A CENTER PIVOT CARRIAGE WITH HYDRAULIC RECOIL CYLINDERS



S

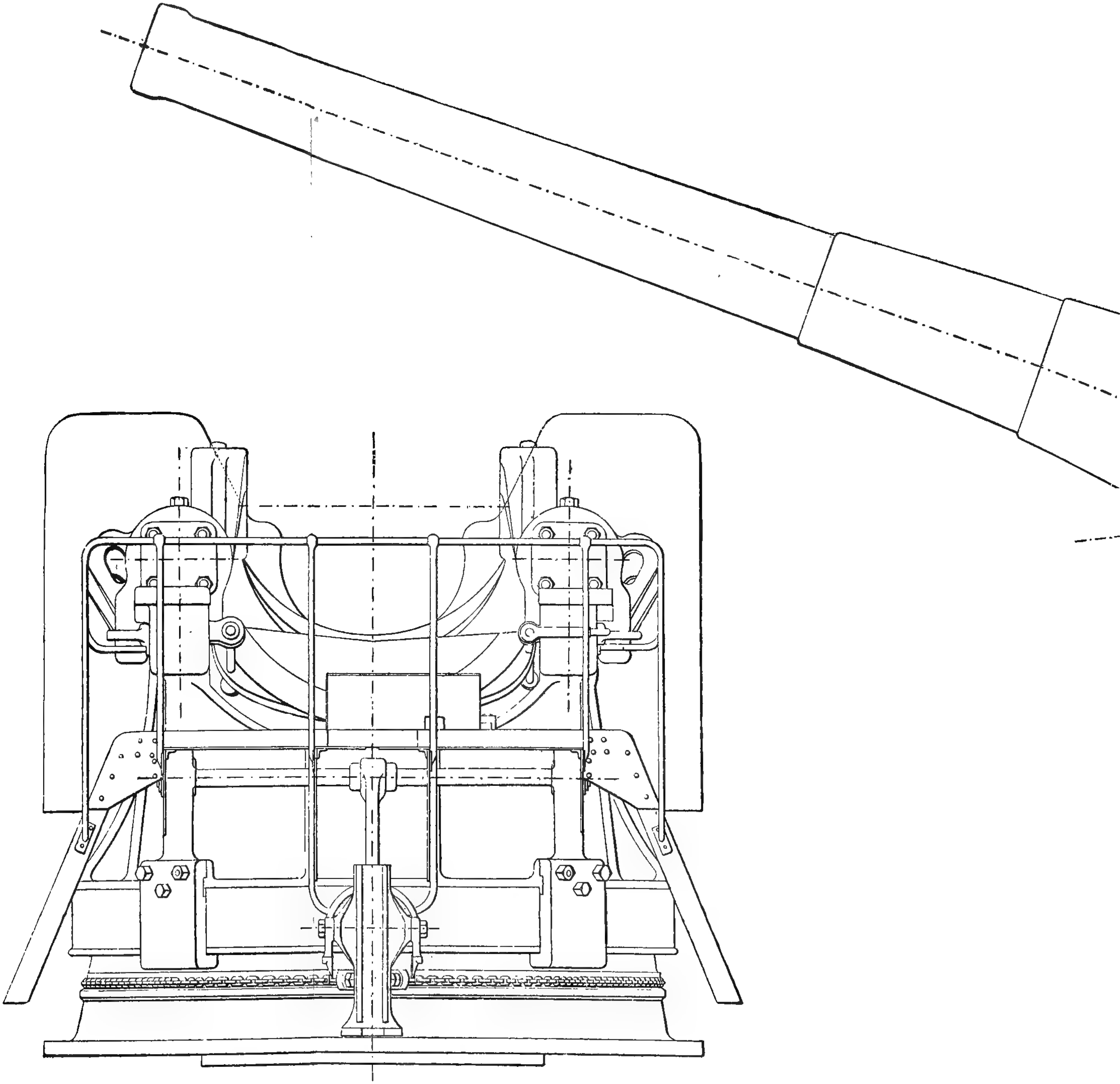
27-CENTIMETER CANET HOWITZER ON A CENTER

Plan.

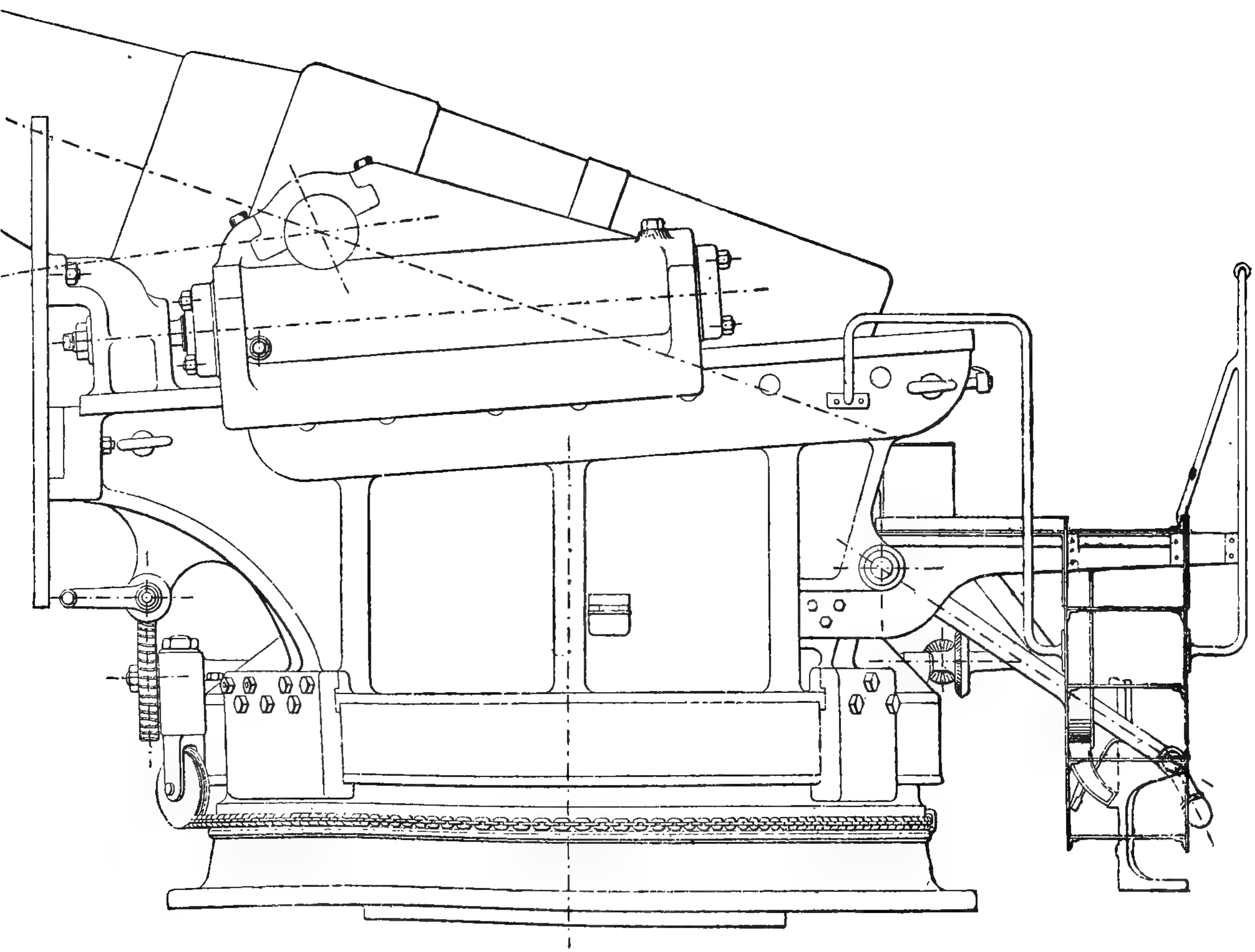


ale $\frac{1}{20}$.

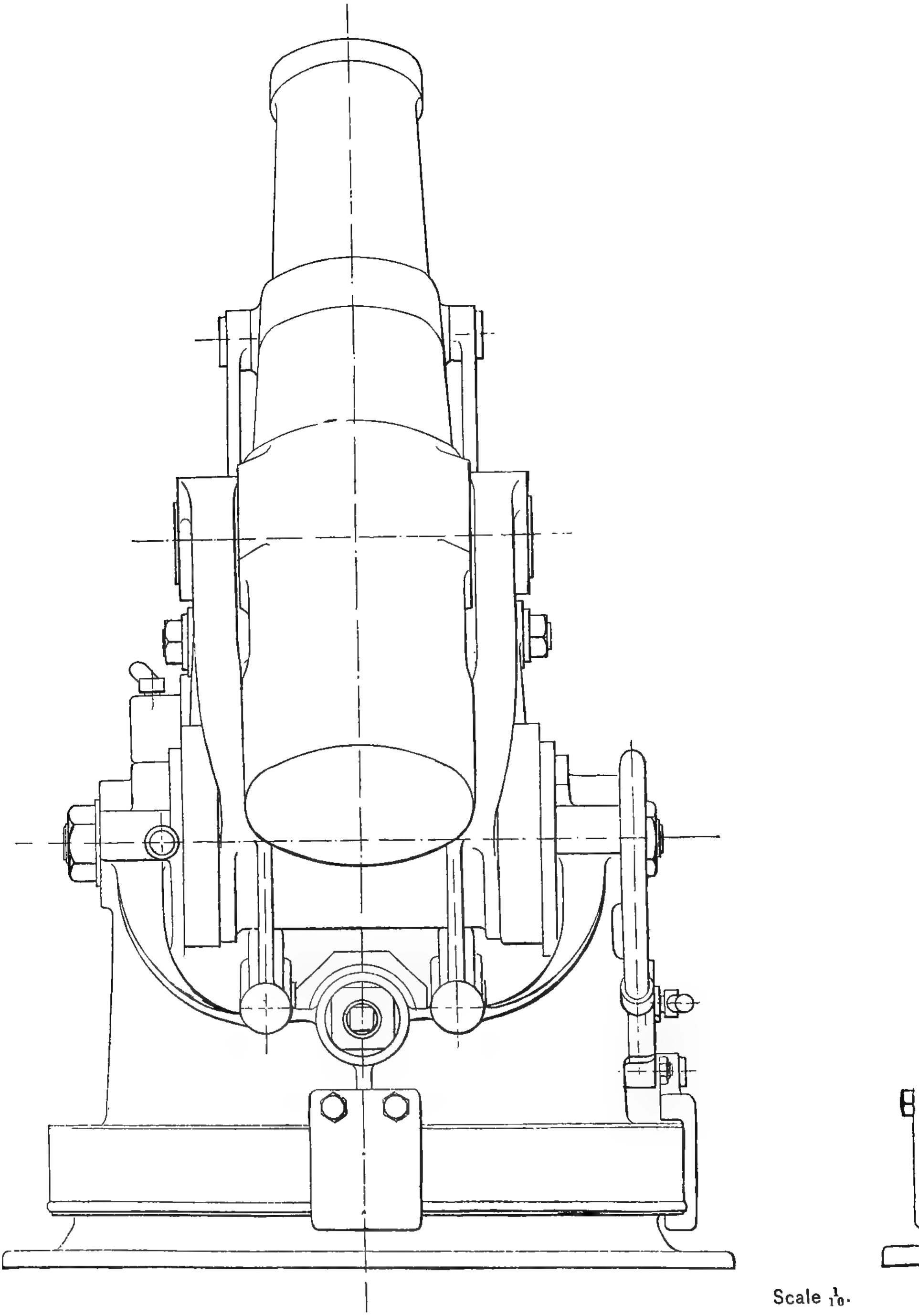
IVOT CARRIAGE WITH HYDRAULIC RECOIL CYLINDERS.



27-CENTIMETER CANET STEEL BREECH-LOADING GUN, 30 CAL

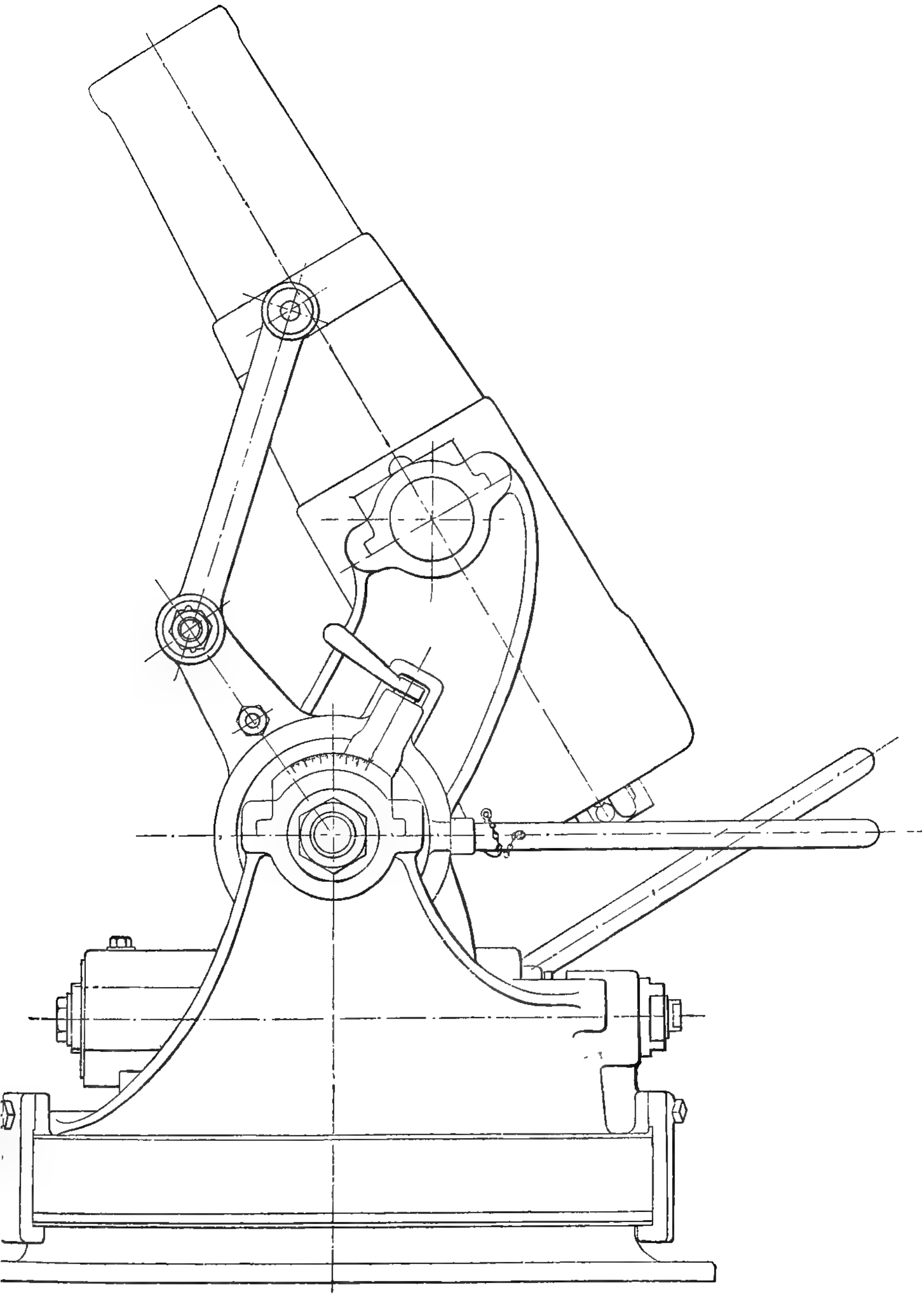


BERS LONG, ON CAST-IRON SEA-COAST CARRIAGE.

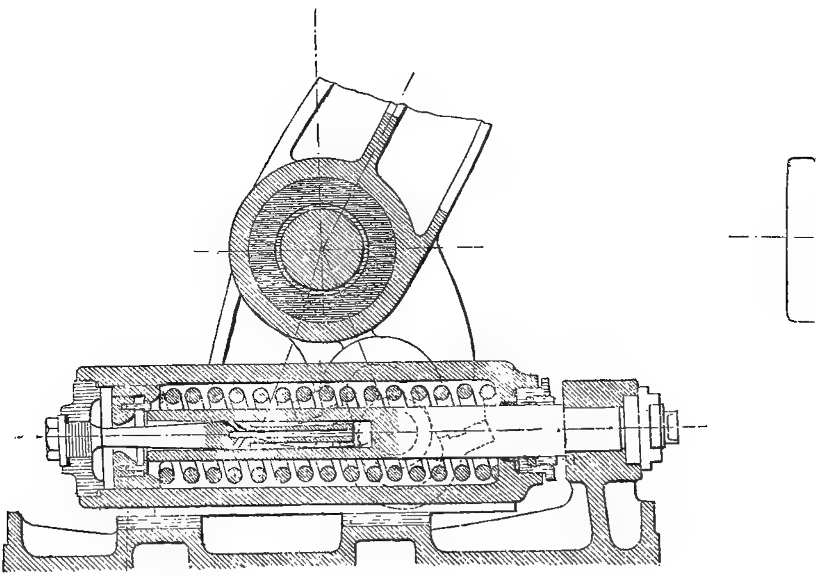


Scale $\frac{1}{10}$.

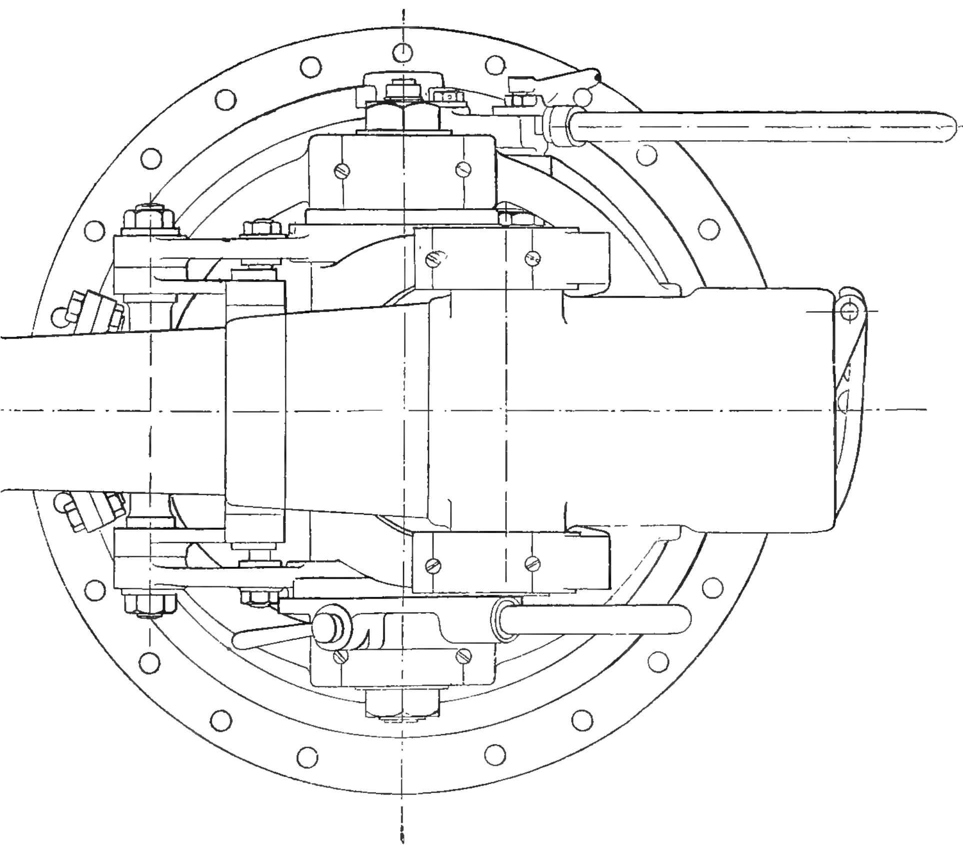
15-CENTIMETER CANET BREECH-LOADING MORTAR ON A CENTE



R PIVOT CARRIAGE WITH HYDRAULIC RECOIL CYLINDERS.

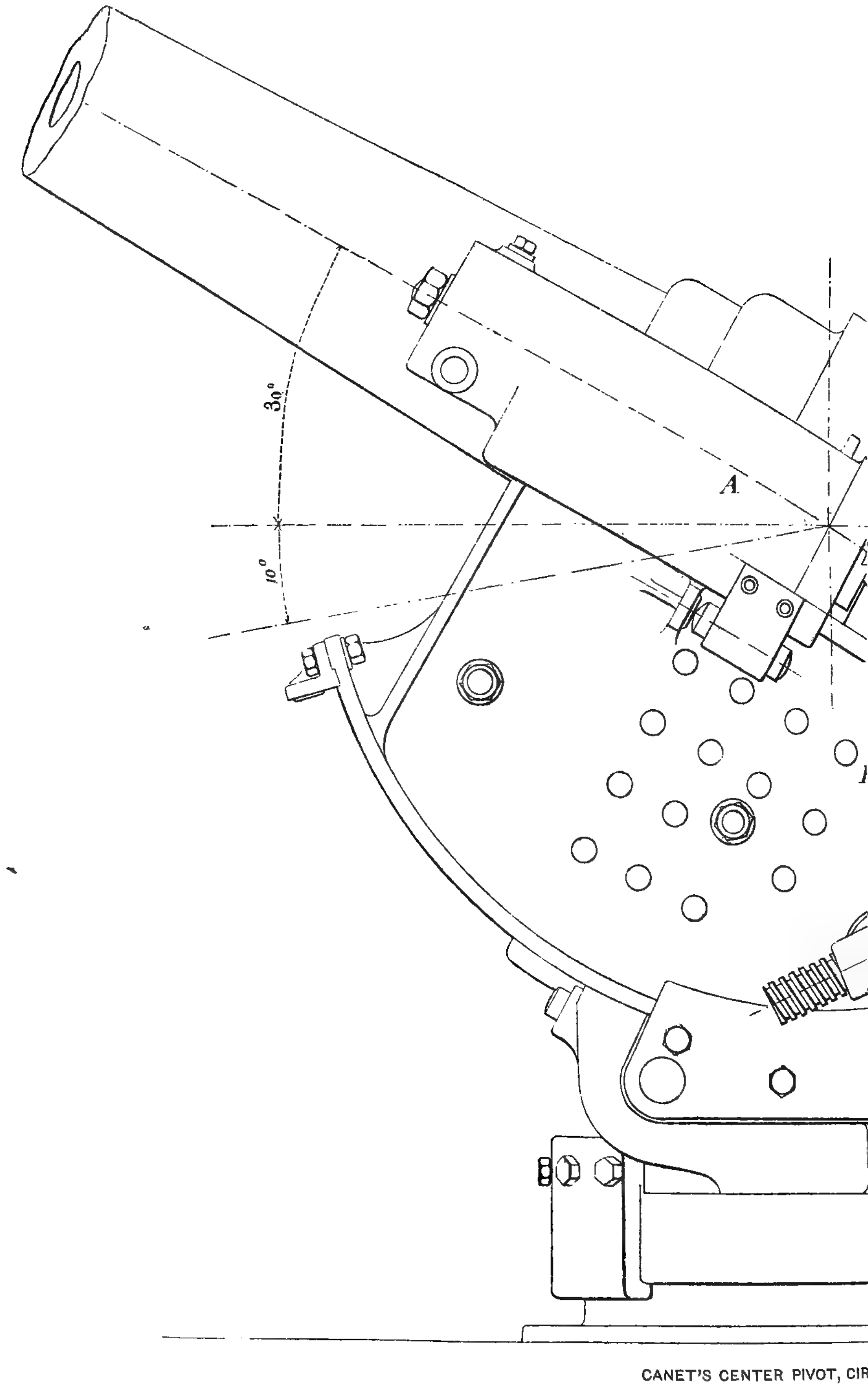


15-CENTIMETER CANET BREECH-LOADING MORTAR

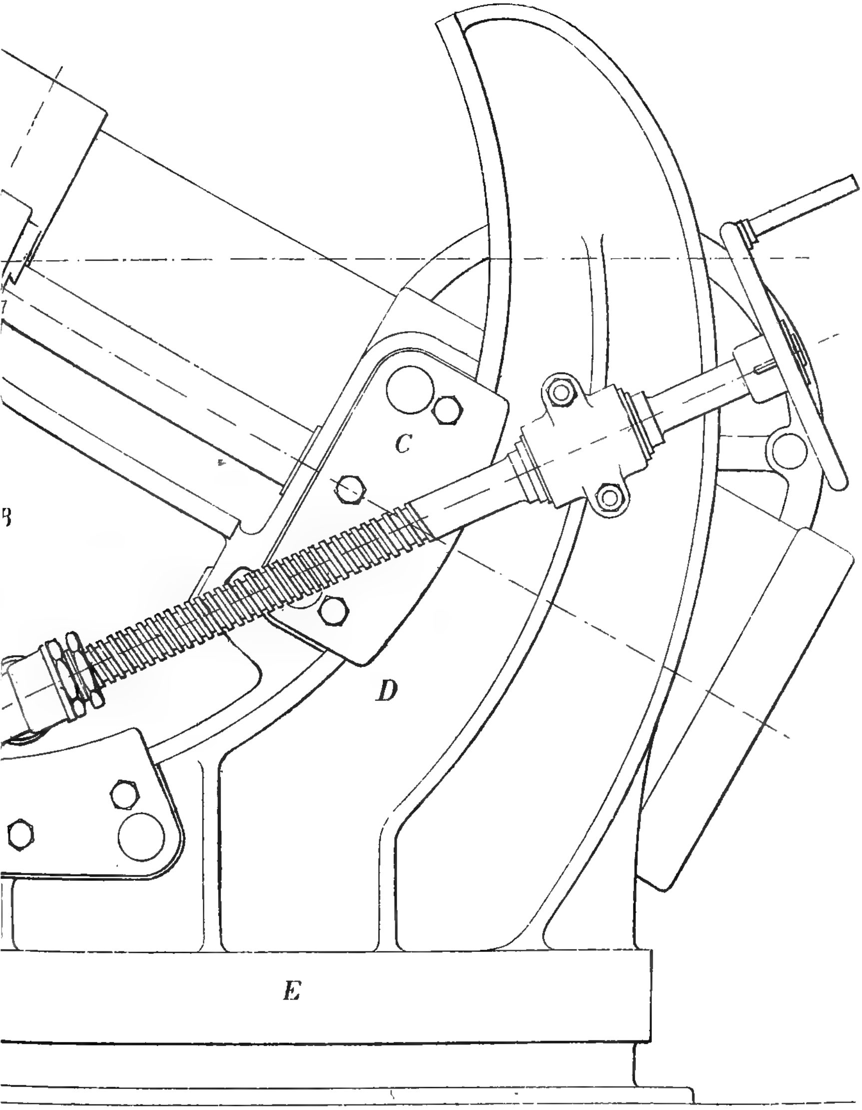


Scale $\frac{1}{10}$.

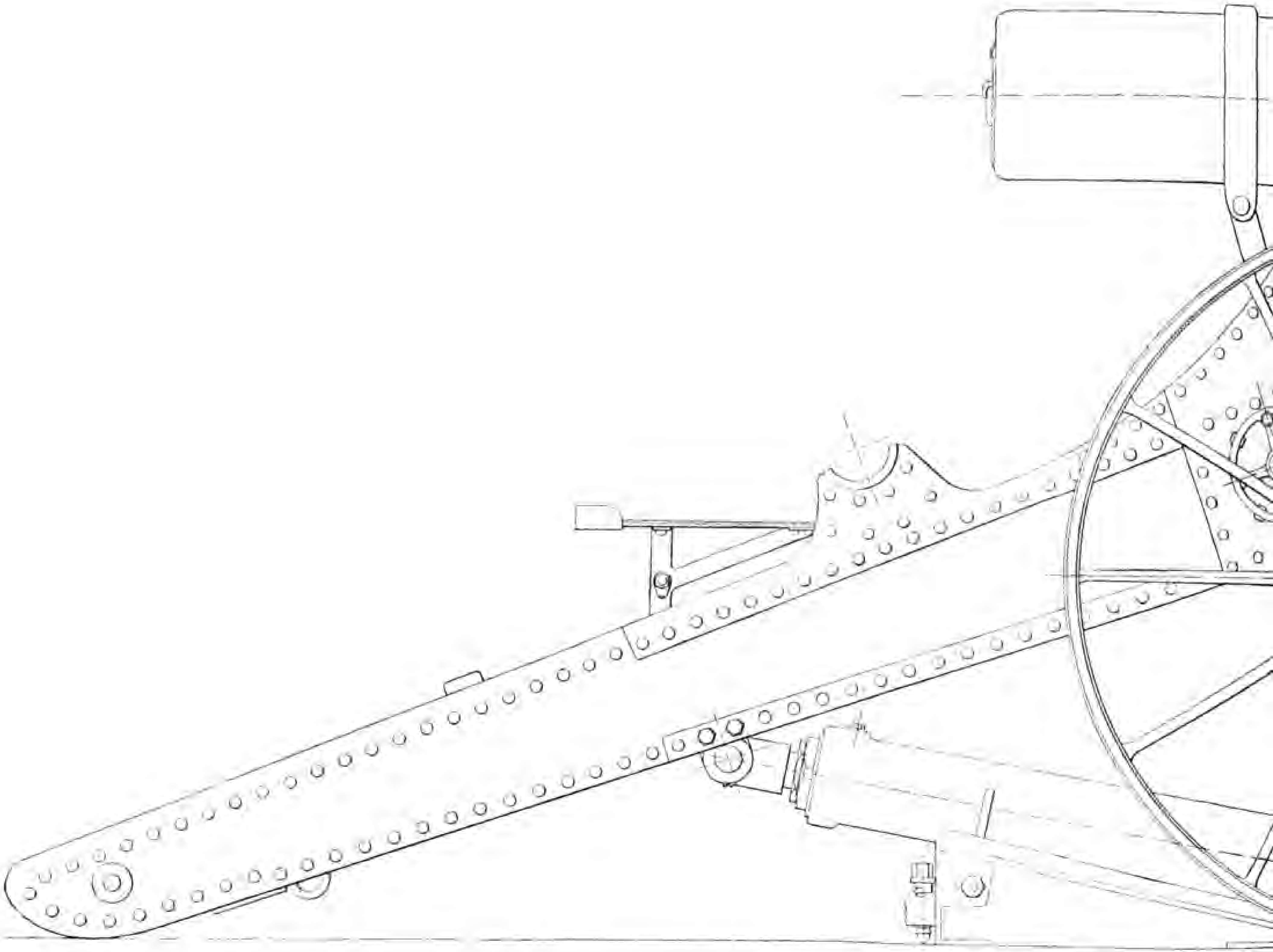
ON A CENTER PIVOT CARRIAGE WITH HYDRAULIC RECOIL CYLINDERS.



CANET'S CENTER PIVOT, CIR

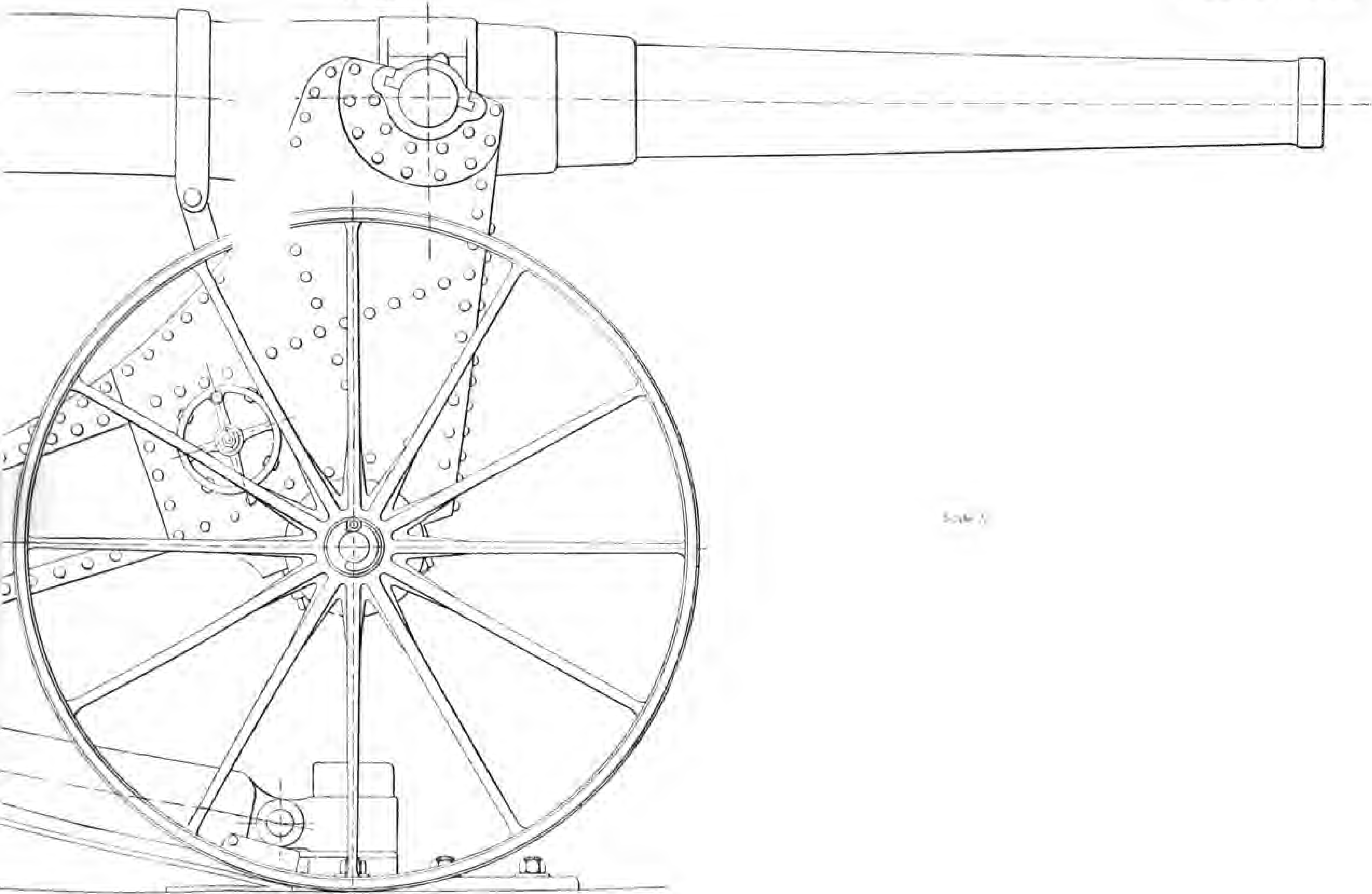


CULAR CHASSIS CARRIAGE.



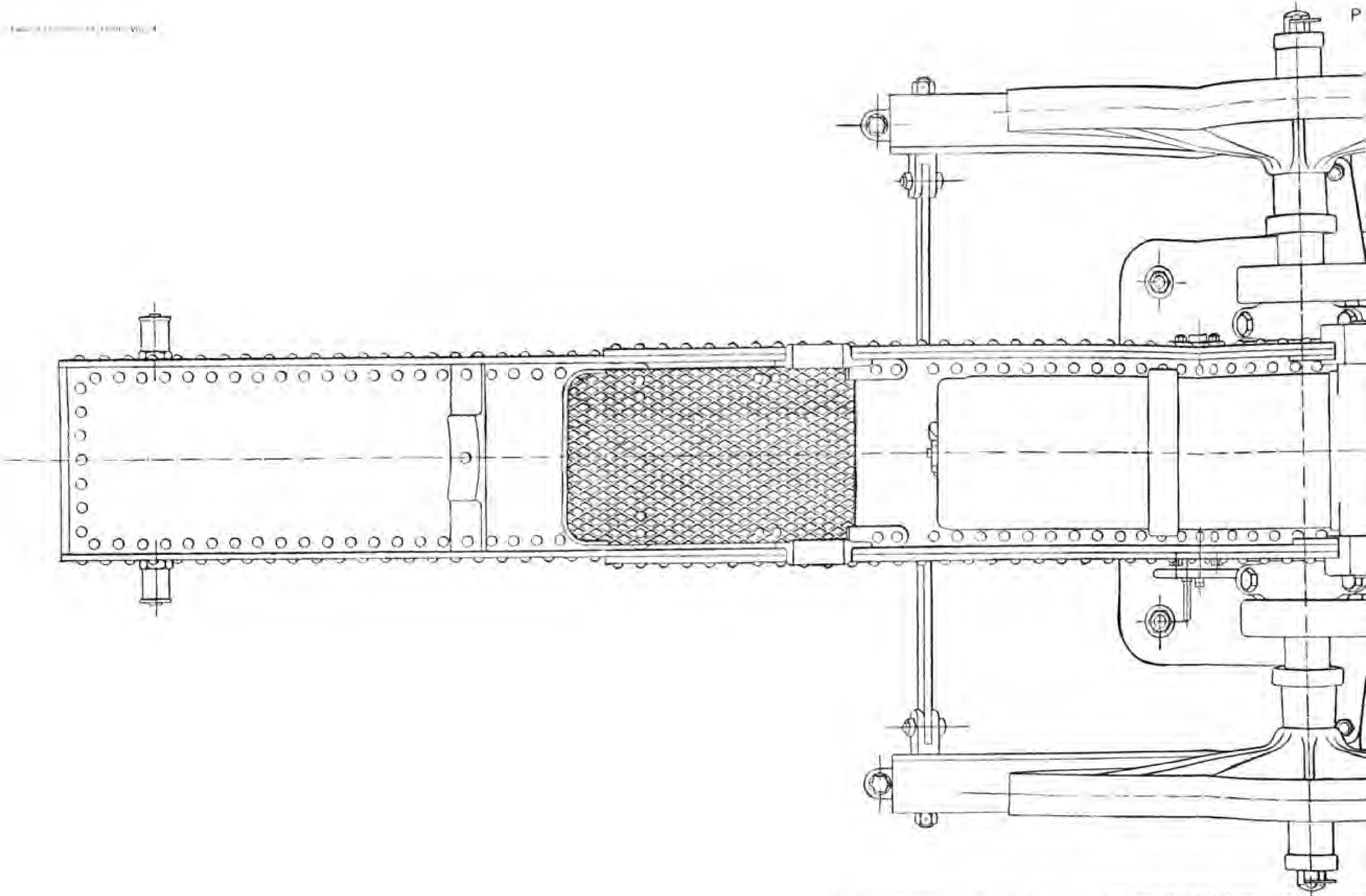
LONG 12-CENTIMETER CANET SIEGE GUN MOUNTED O

Elevation.

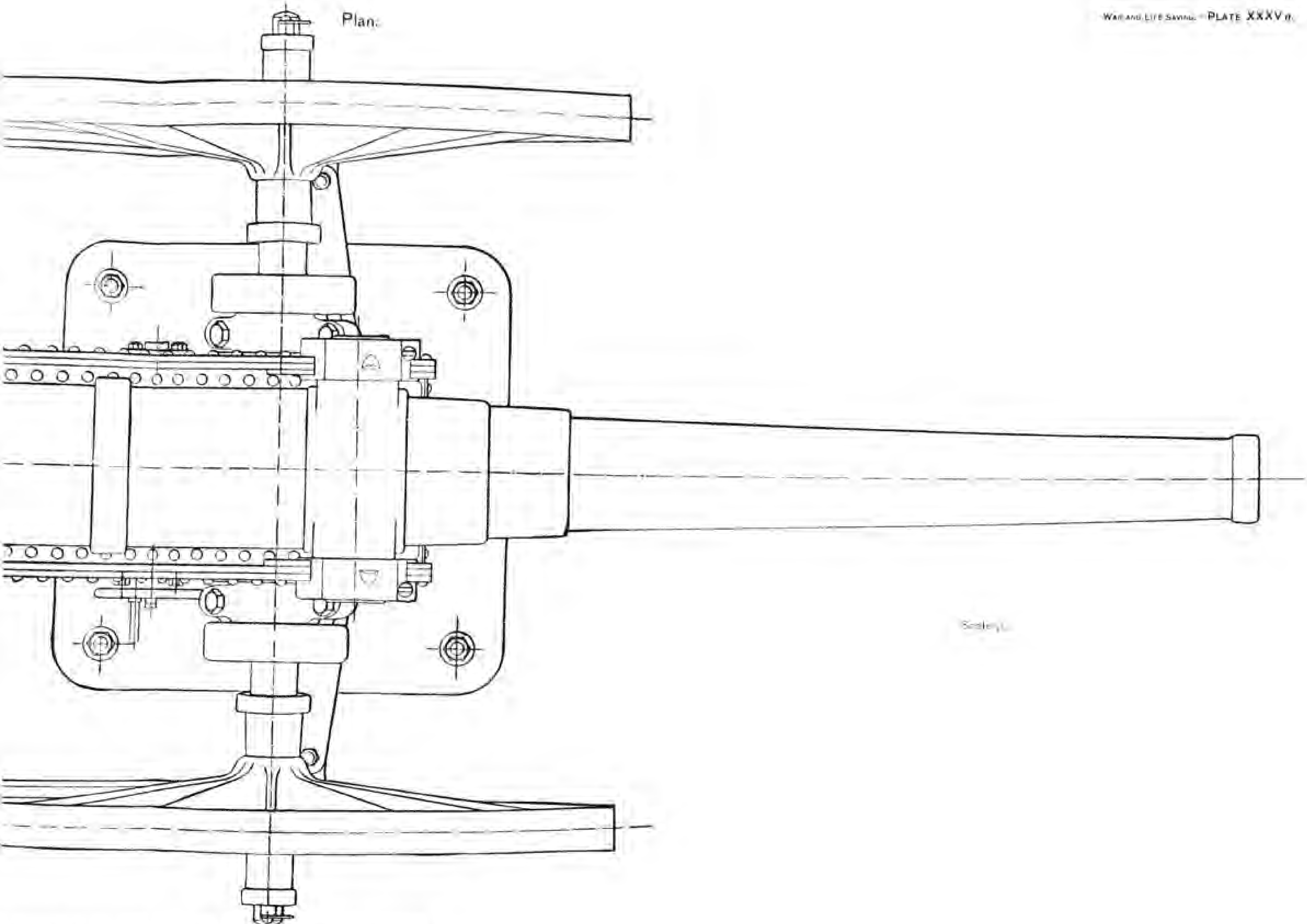


Scale

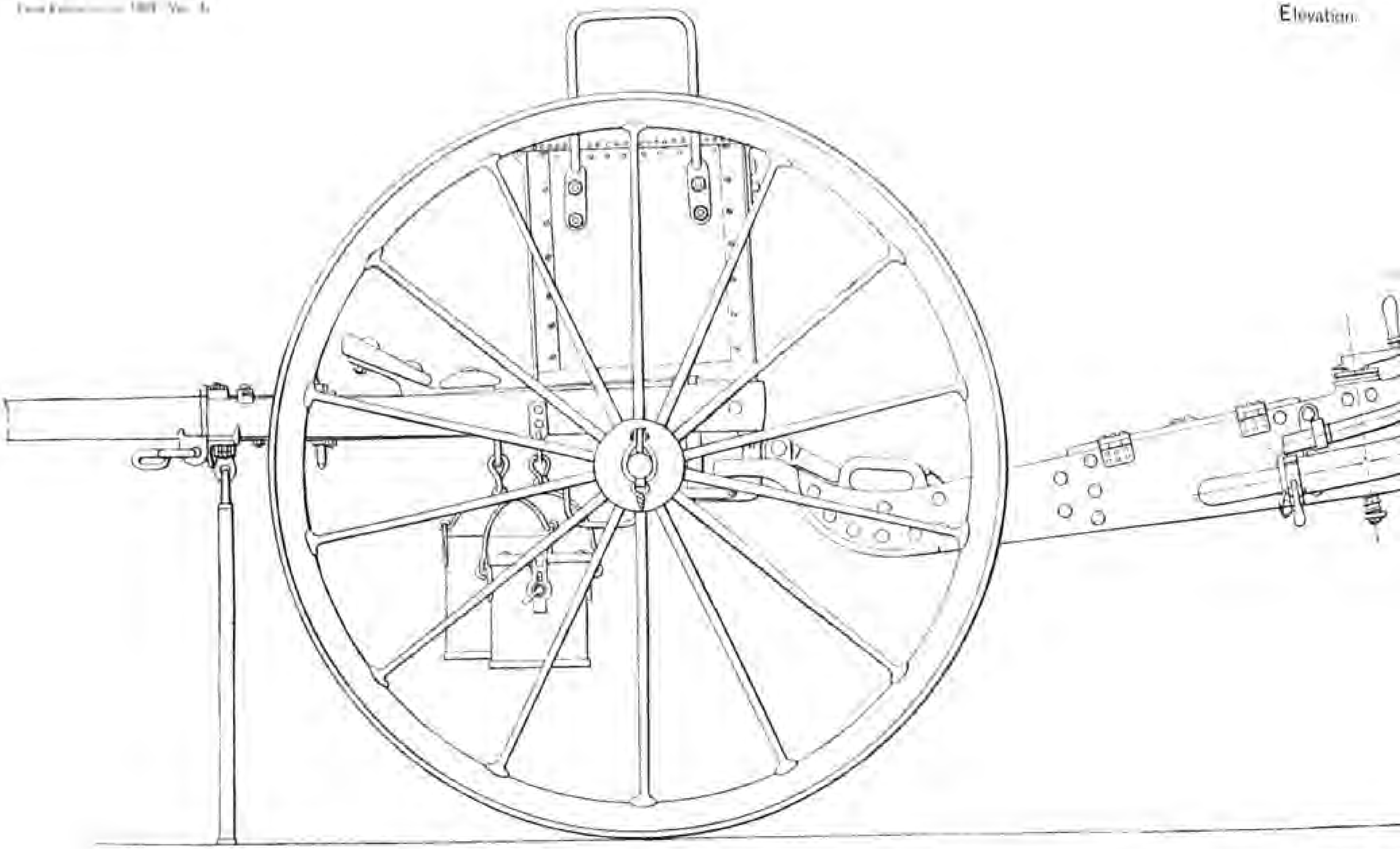
CANET SIEGE GUN MOUNTED ON SIEGE CARRIAGE WITH HYDRAULIC CYLINDERS.



LONG 12-CENTIMETER CANET SIEGE GUN MOUNTED ON SIEGE CARRIAGE WITH HYDRAU

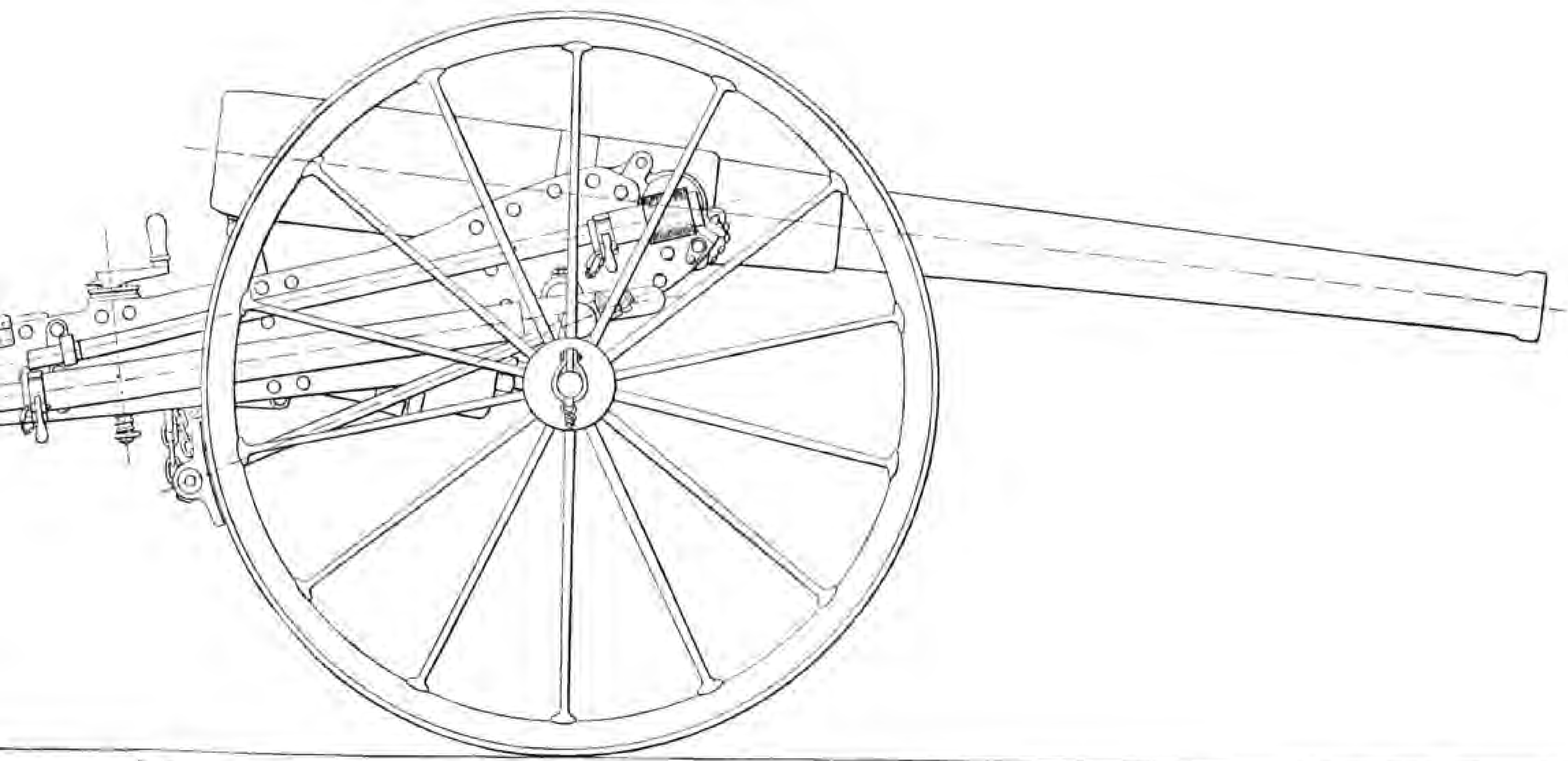


N MOUNTED ON SIEGE CARRIAGE WITH HYDRAULIC CYLINDERS.



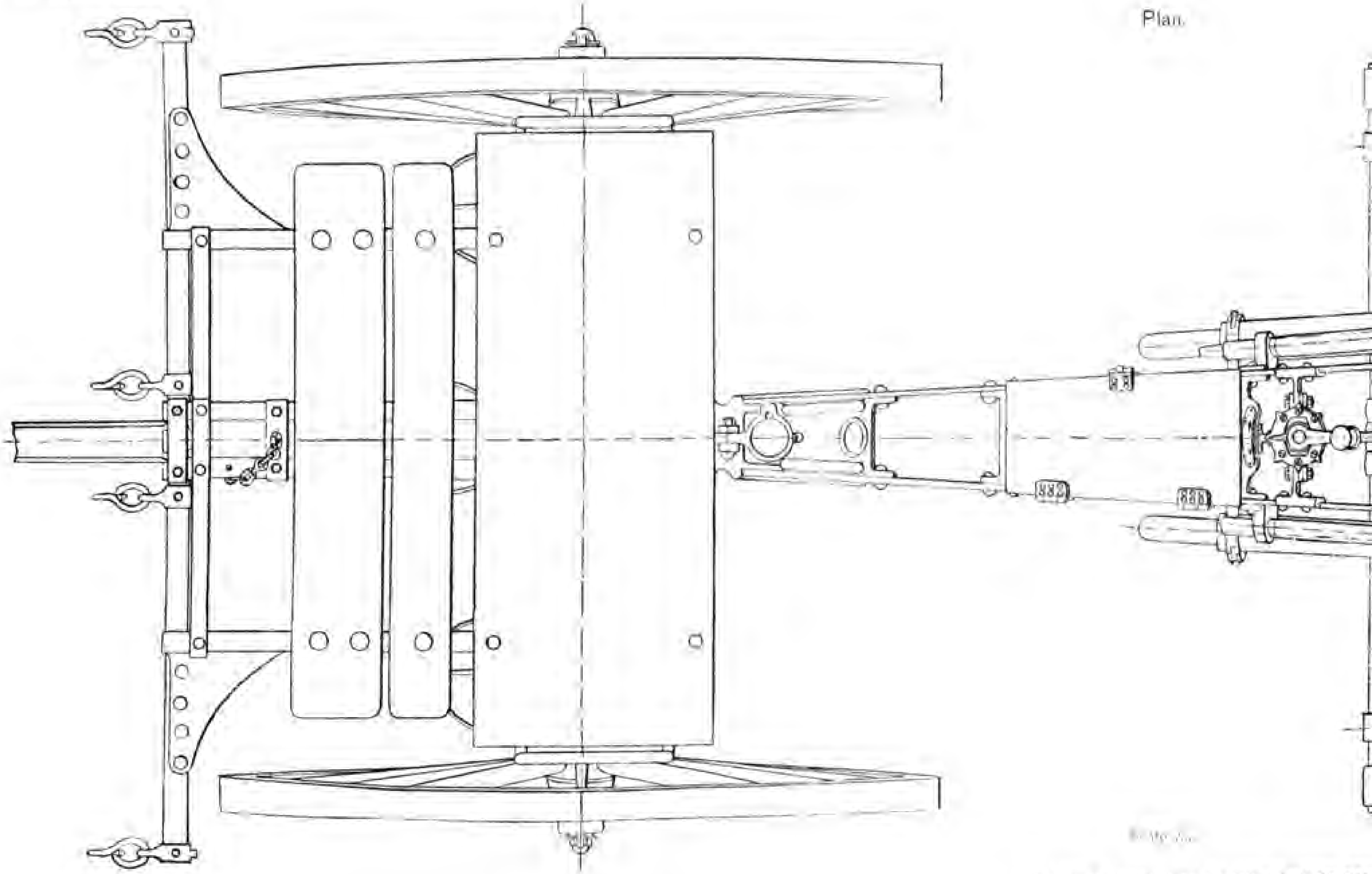
LONG 75-MILLIMETER CANET GUN

Elevation.

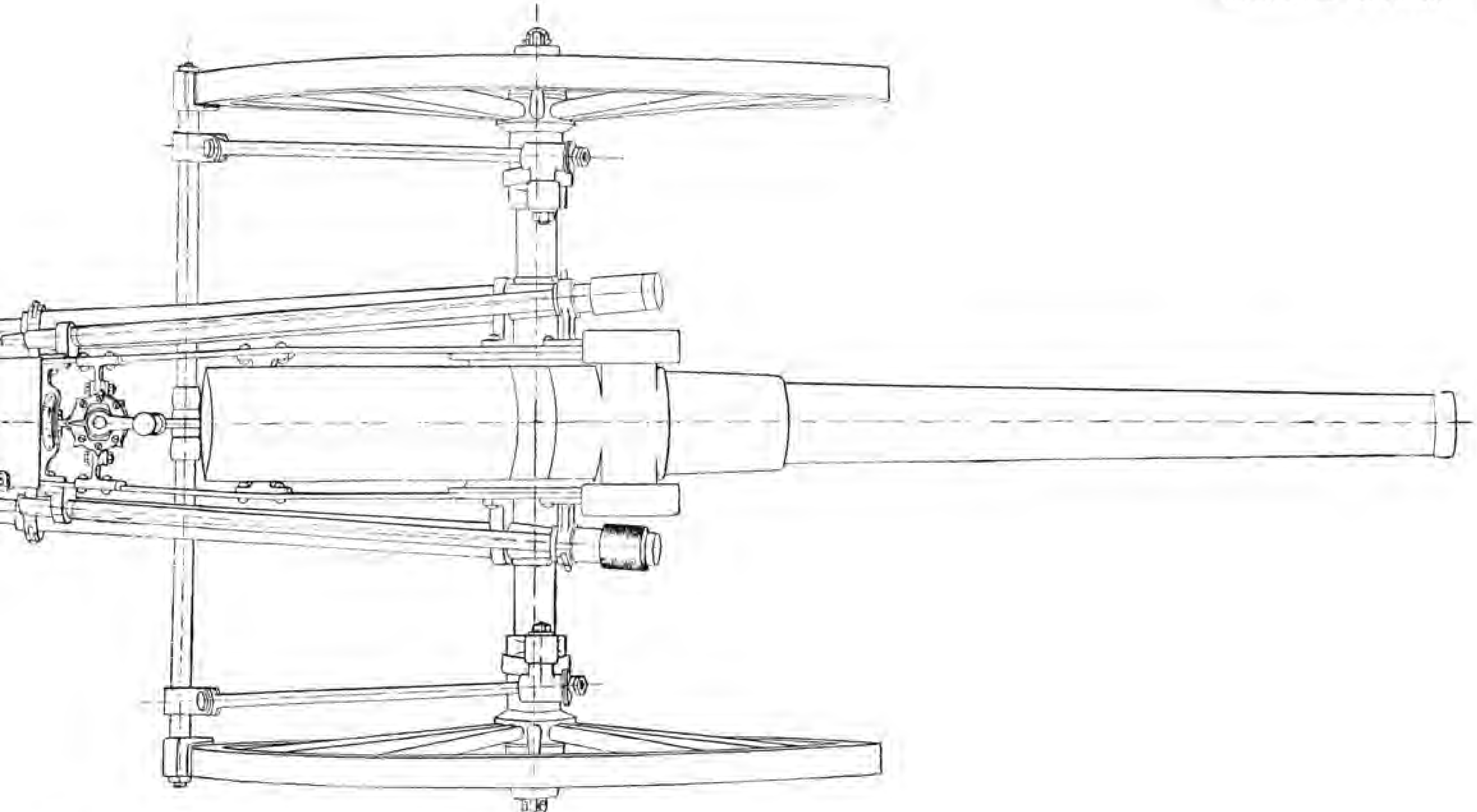


Scale

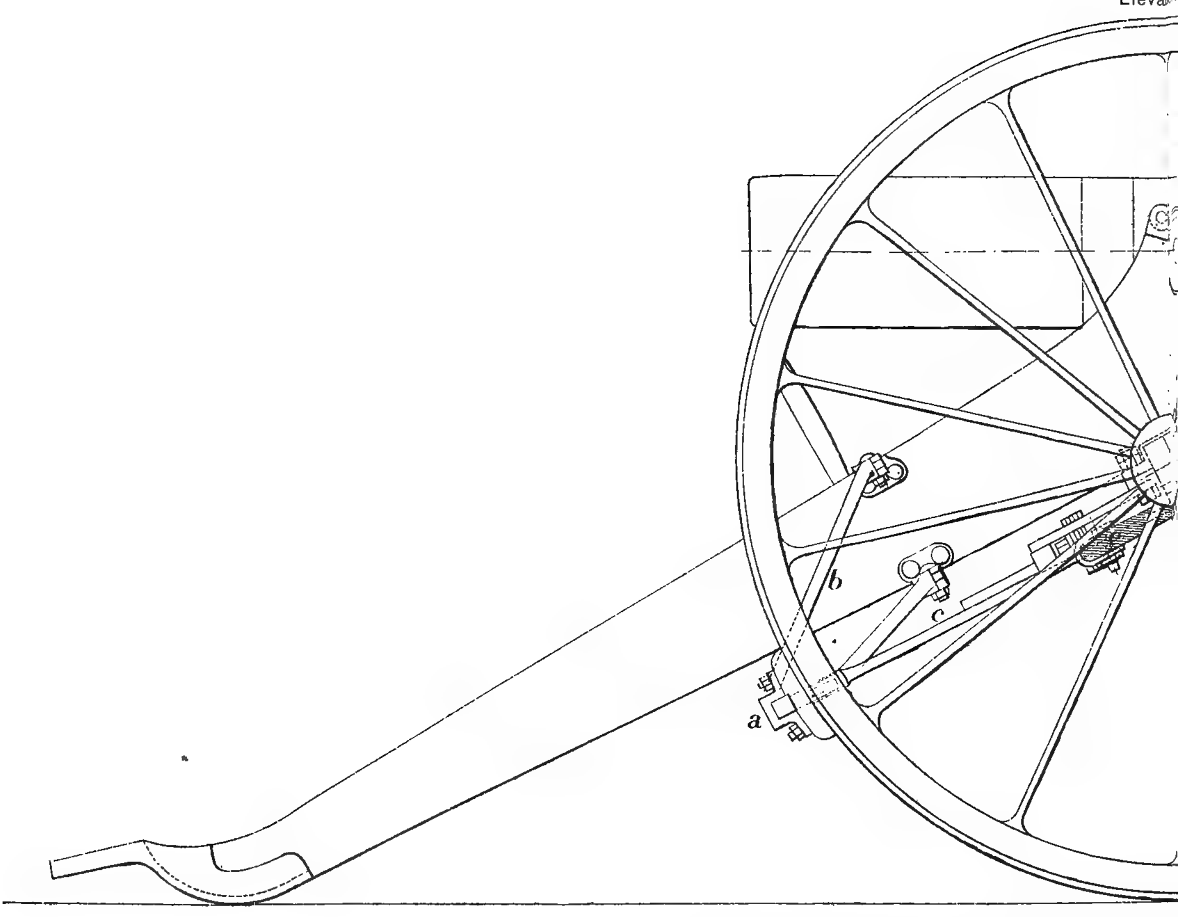
R CANET GUN ON FIELD CARRIAGE, WITH INDEPENDENT AXLE



LONG 75 MILLIMETER CANET GUN ON FIEL

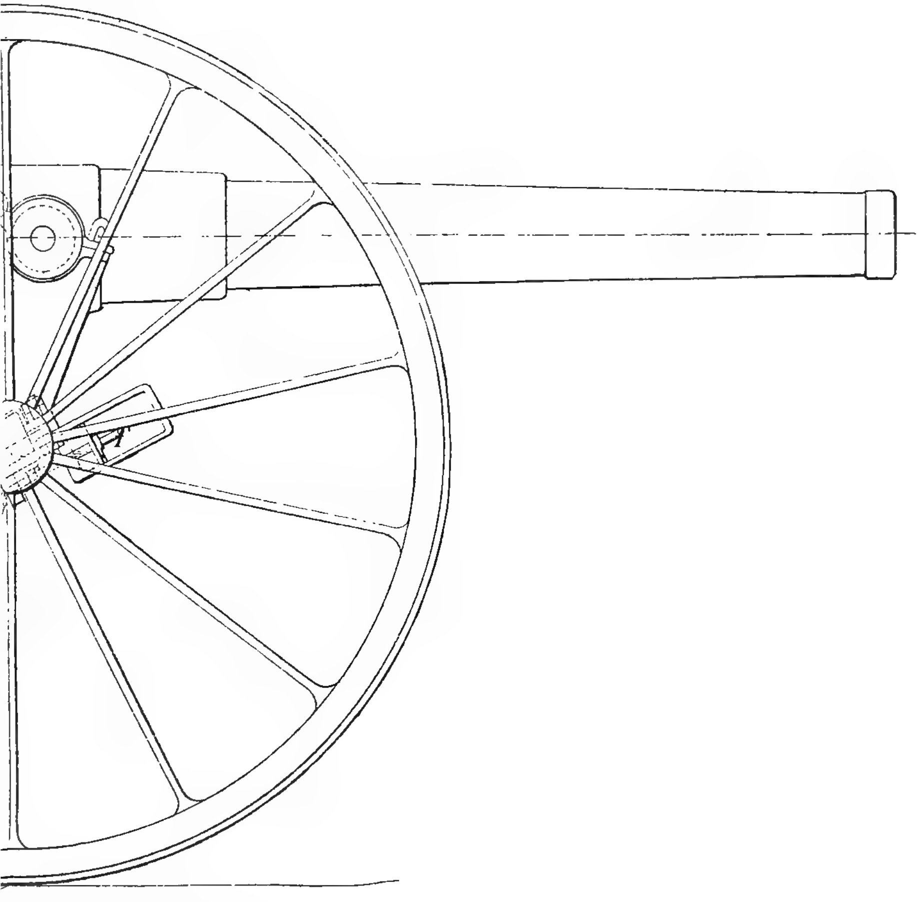


…R CANET GUN ON FIELD CARRIAGE, WITH INDEPENDENT AXLE.

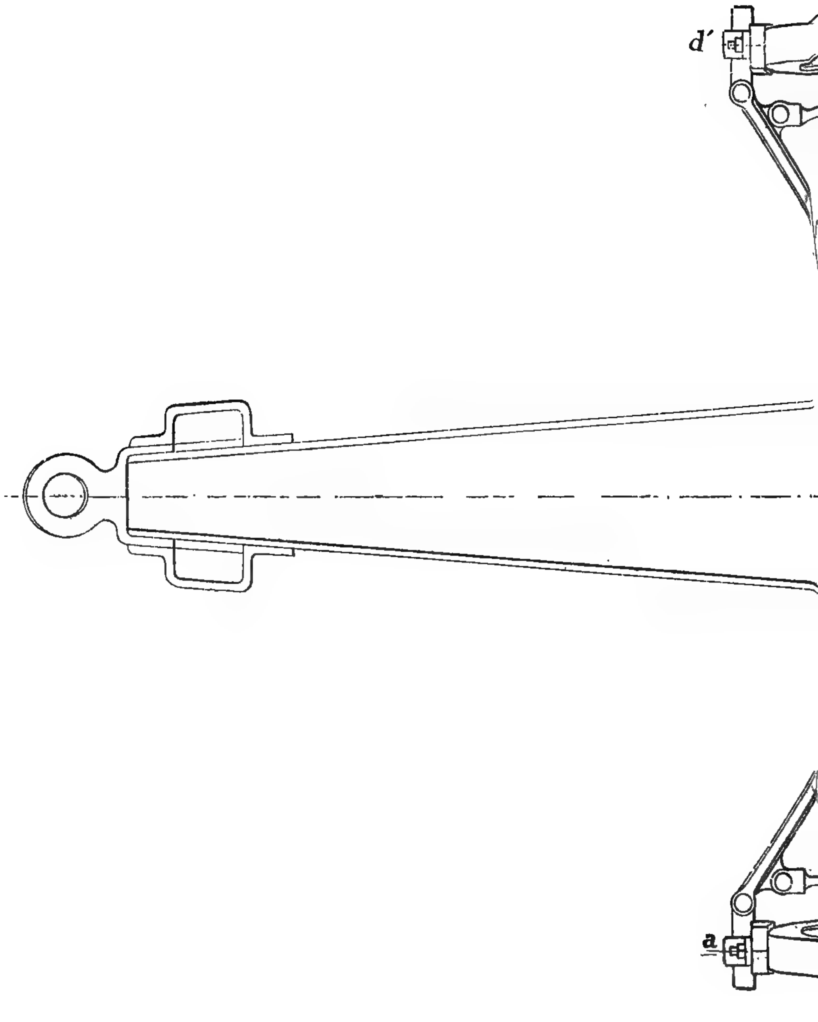


75-MILLIMETER CANET GUN ON LIGHT FIELD CARRIAGE, SH

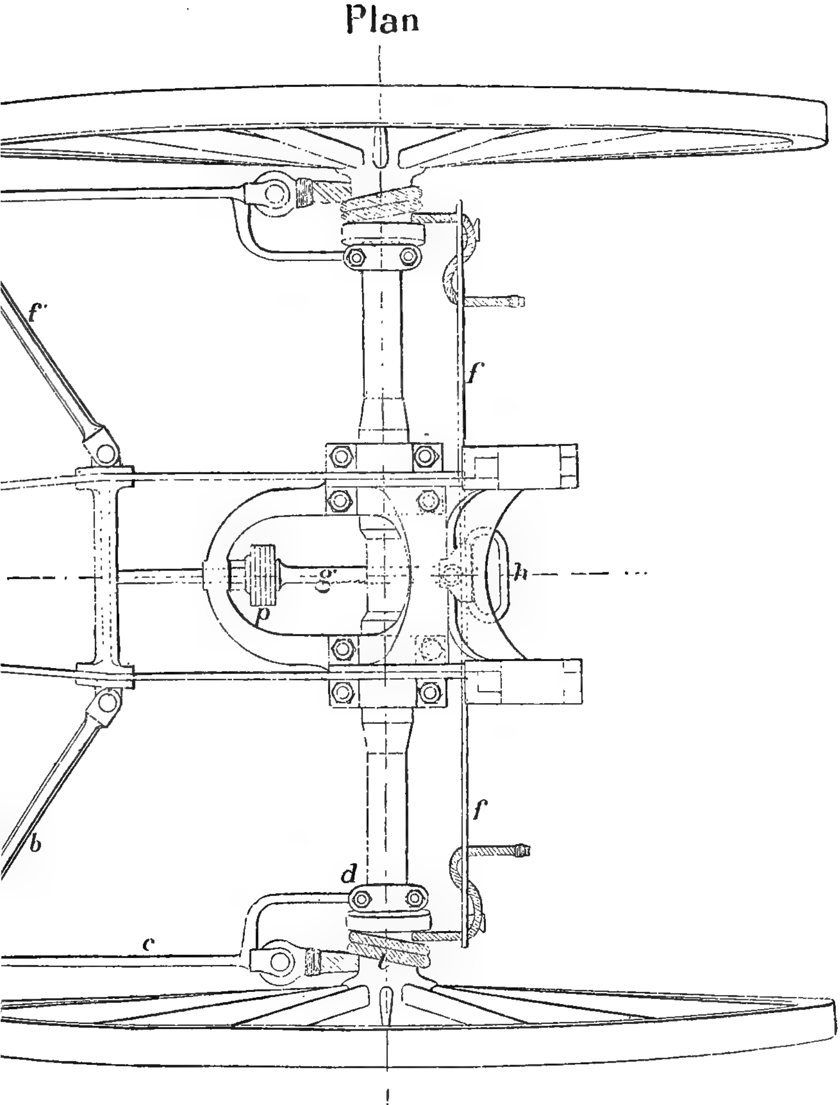
tion.



OWING THE LEMOINE BRAKE.

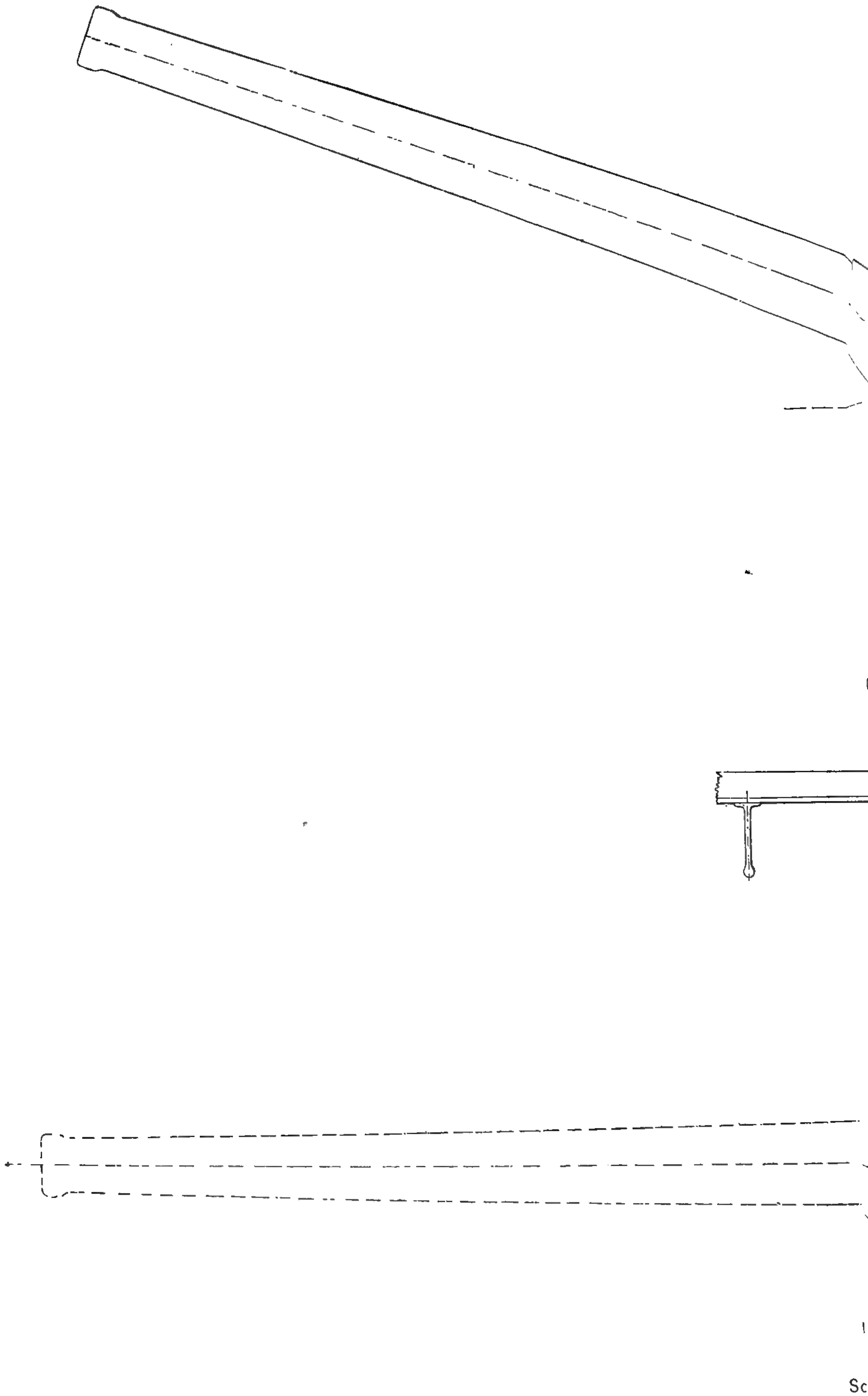


75-MILLIMETER CANET GUN ON LIGHT FIEL

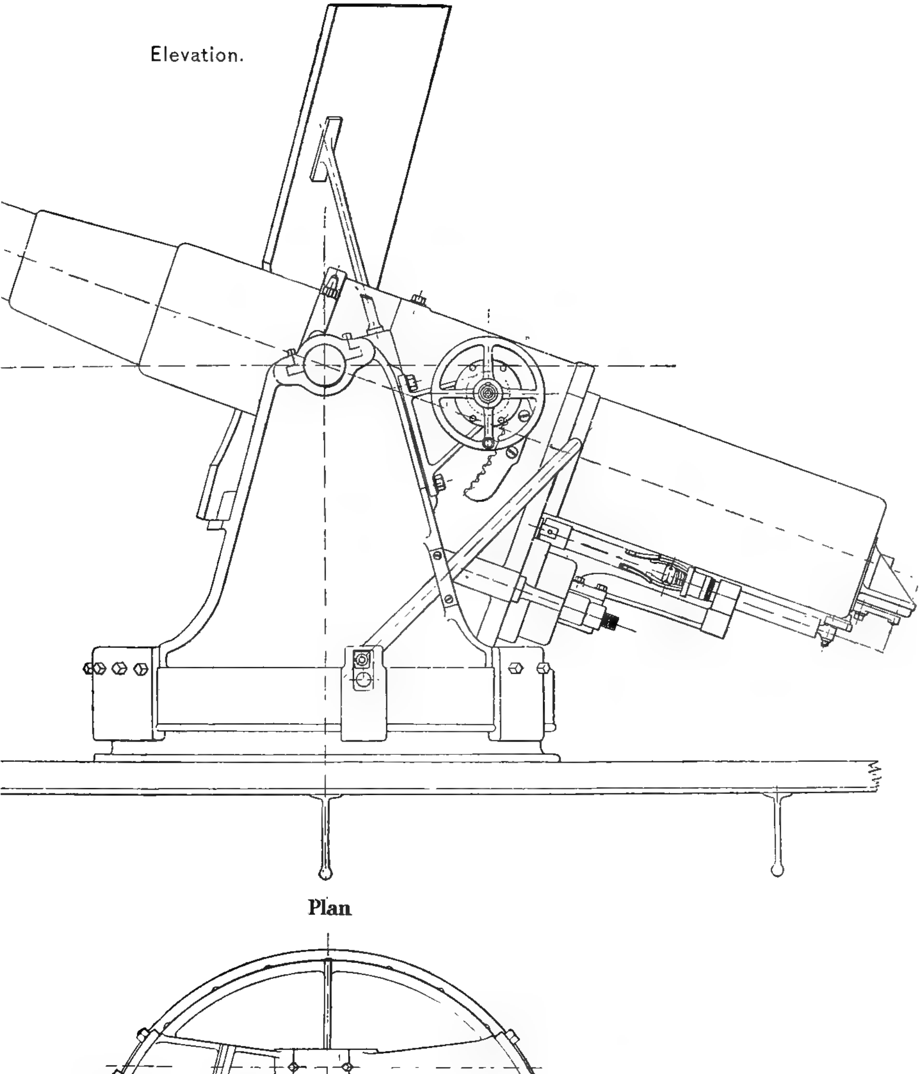


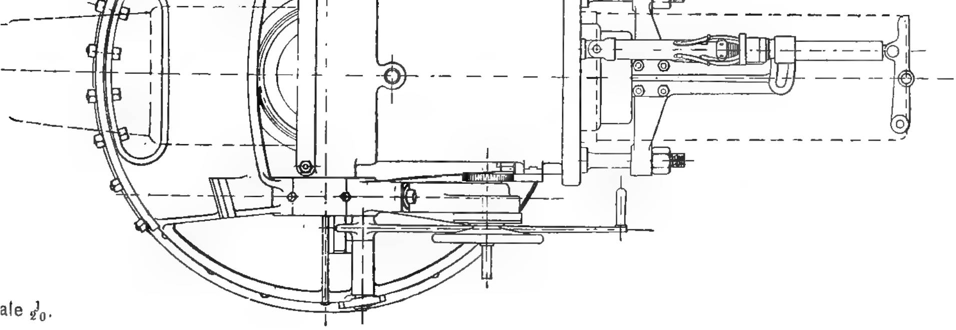
Scale $\frac{1}{10}$.

D CARRIAGE, SHOWING THE LEMOINE BRAKE.



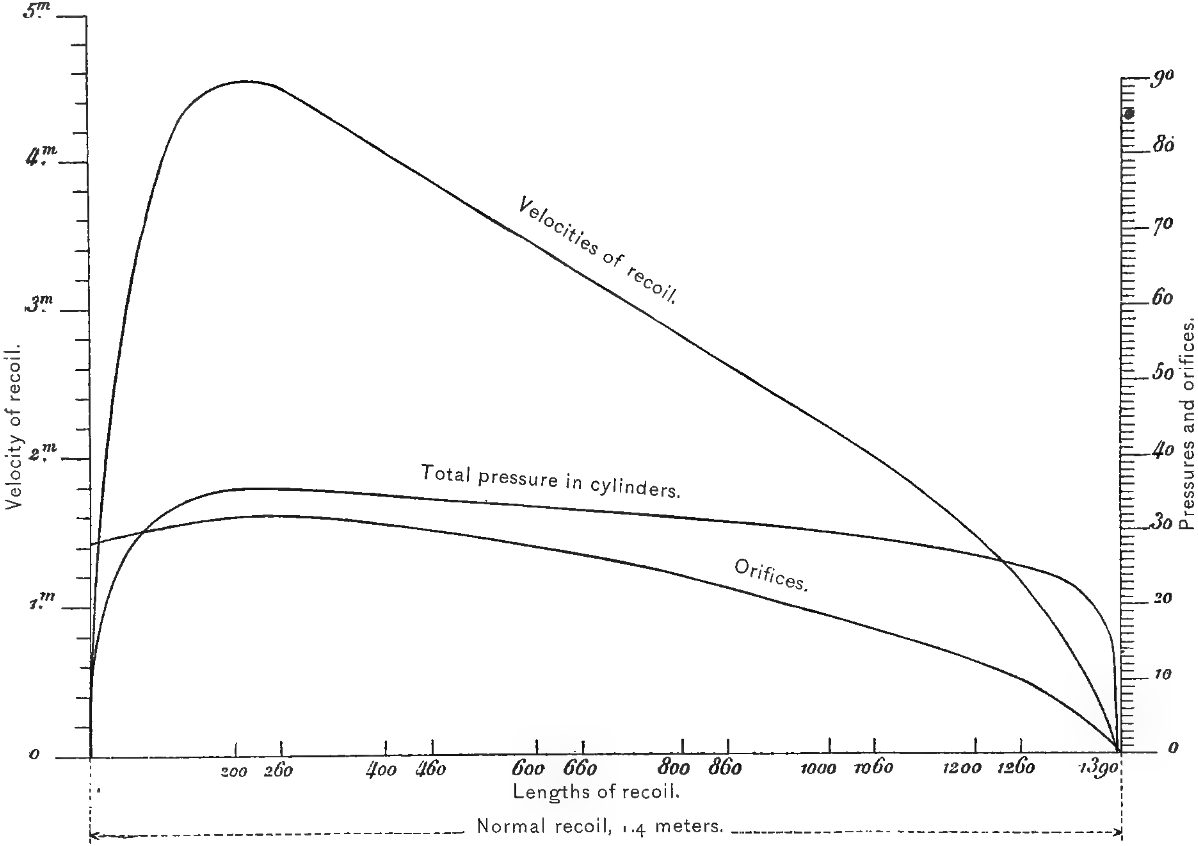
10-CENTIMETER CANET RAPID-FIRING G





ale $\frac{1}{20}$.

JN, 48 CALIBERS LONG. MODEL OF 1888.



Scale of pressures. = 1mm per 1,000 kilograms.

Scale of orifices. . . = 1mm per square centimeter

Scale of velocities of recoil . . . . = 20mm per meter.

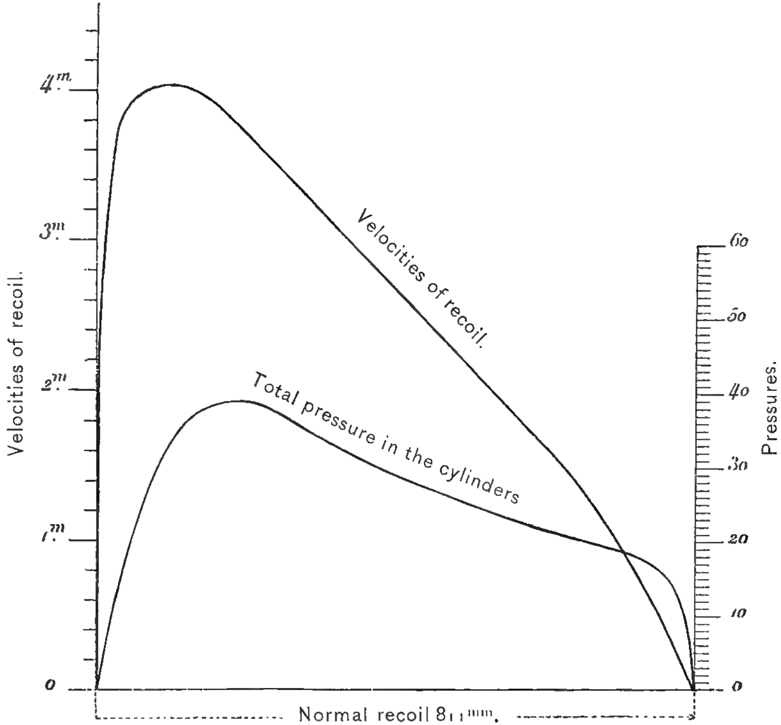
Weight of projectile . . . . . 342 kilograms.

Weight of charge . . . . 115 kilograms.

Initial velocity . . . . 560 meters.

CANET CENTER PIVOT SEA-COAST CARRIAGE FOR 32-CENTIMETER GUN.

Curves of velocities of recoil and of pressures obtained in the cylinders. The brake is a central sliding piston, Canet system.



Scale of pressures.... ... ..4 mm per 1,000 kilograms.

Scale of velocities of recoil = 20mm per meter.

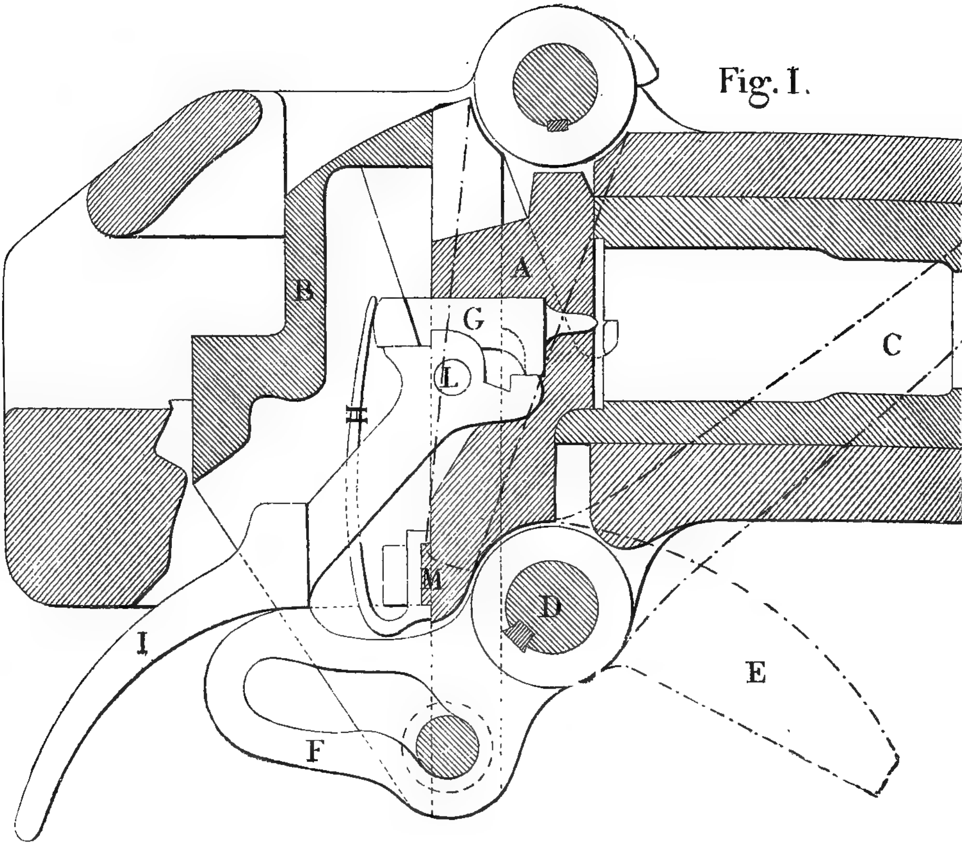
Weight of projectile....... = 200 kilograms.

Weight of charge.......... = 13.5 kilograms.

Initial velocity .... = 270 meters per second.

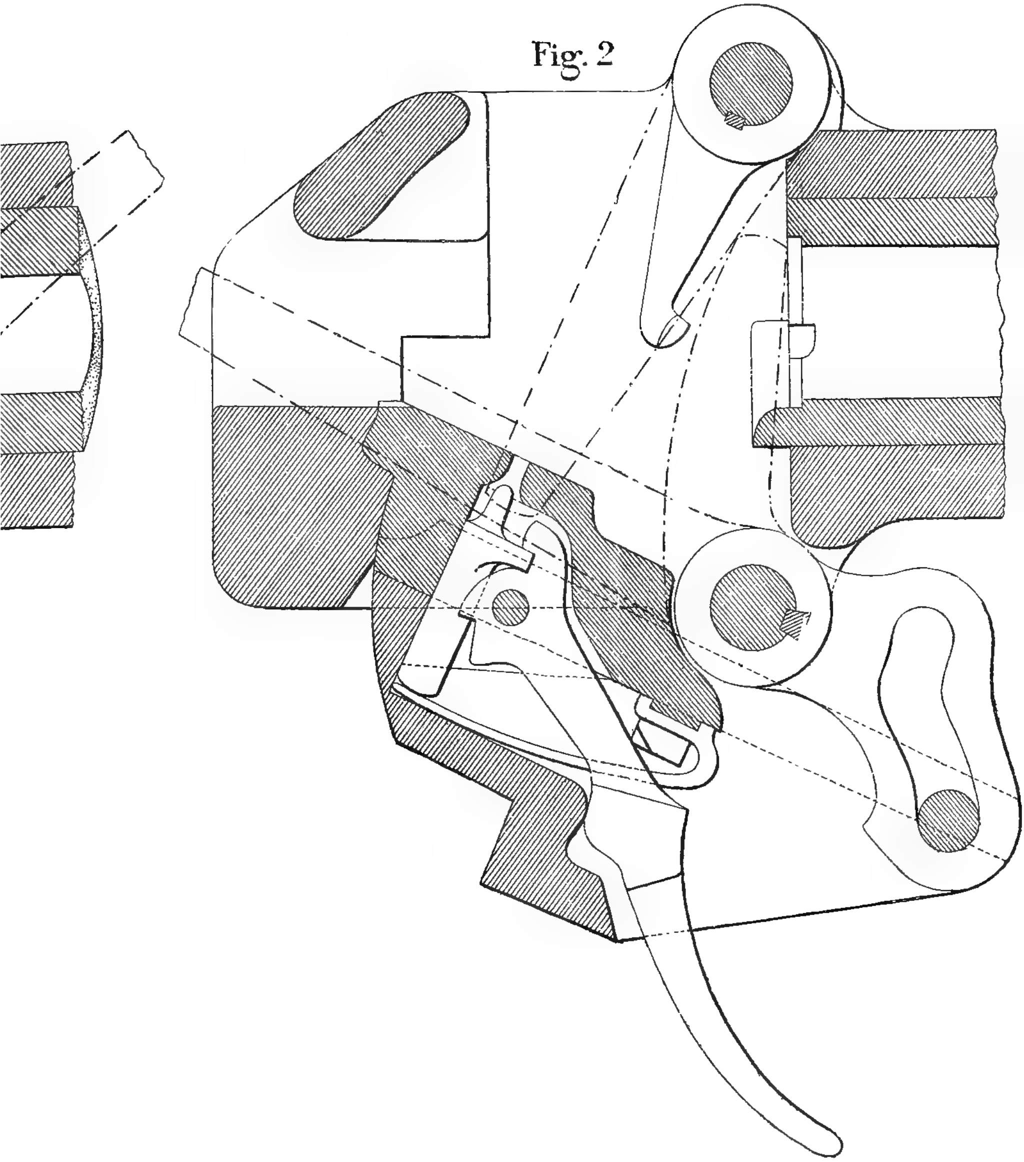
CANET'S CENTER PIVOT SEACOAST CARRIAGE FOR 27-CENTIMETER MORTAR.

Curves of the velocities of recoil and of the pressures obtained in the cylinders. The brake has the Vavasseur-Canet rotating valve.

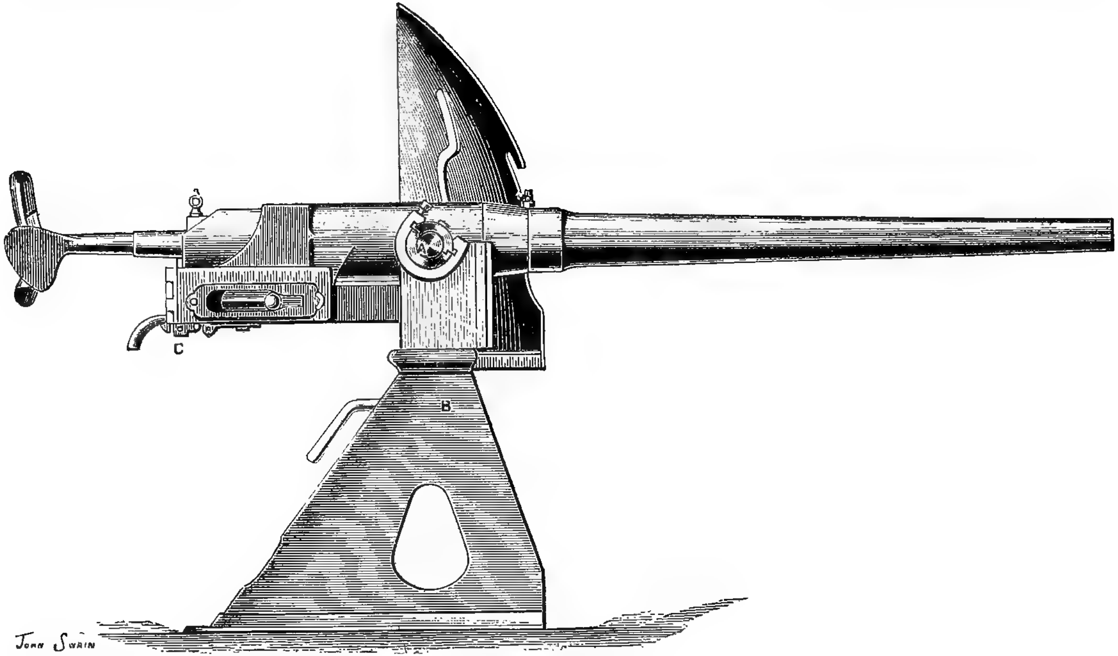


BREECH FERMETURE OF N

Fig. 2



NORDENFELT RAPID-FIRING GUNS.



SIX-POUNDER QUICK-FIRING GUN.

[From *The Engineer*, London.

Fig. 1.

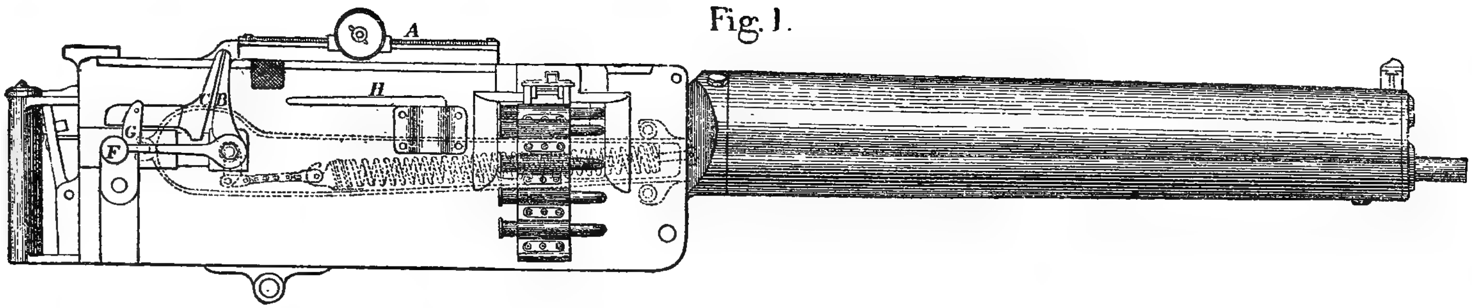


Fig. 2.

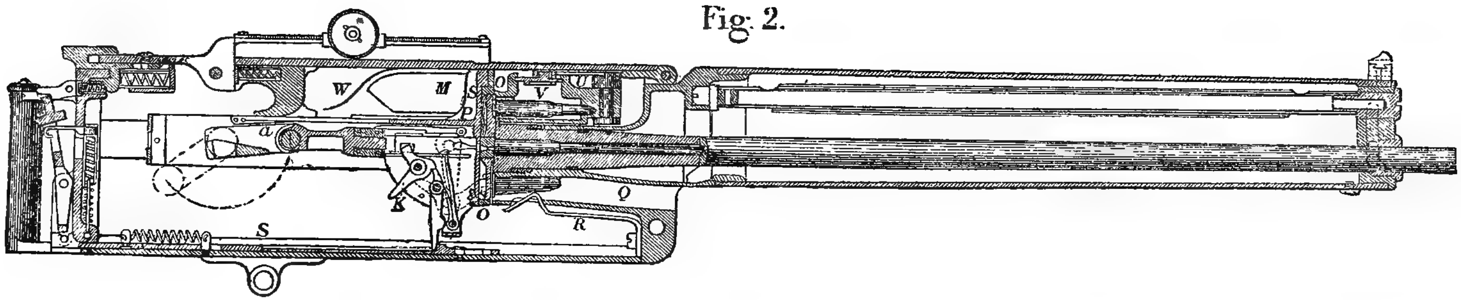


Fig. 3.

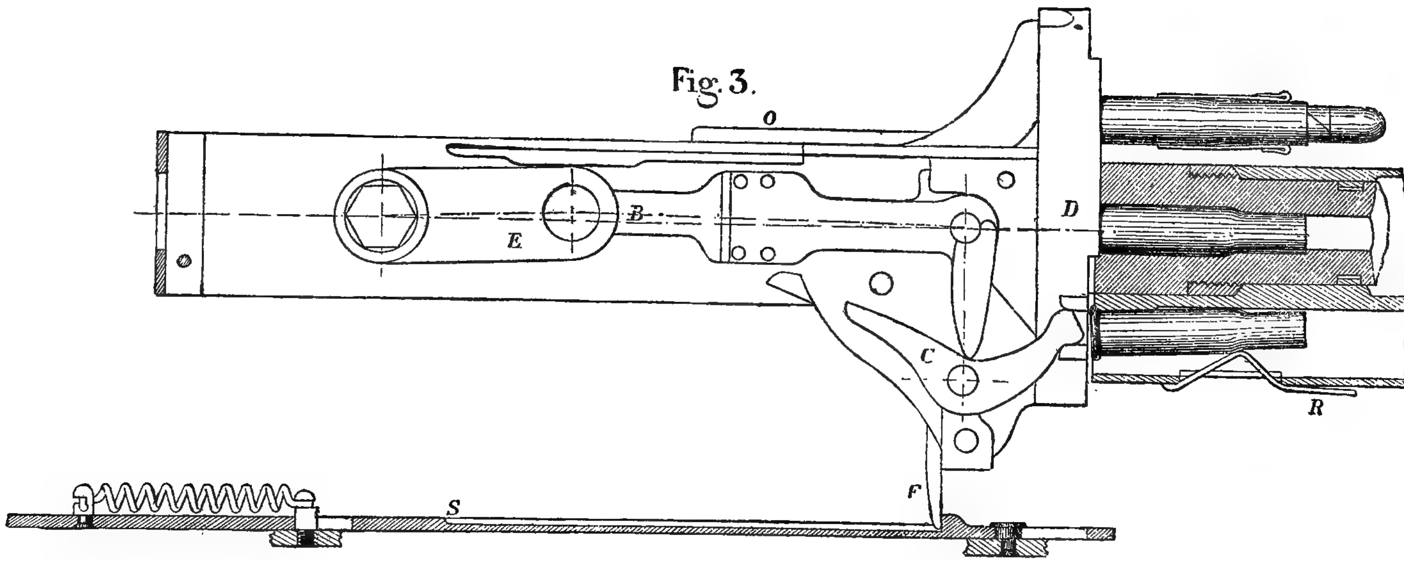
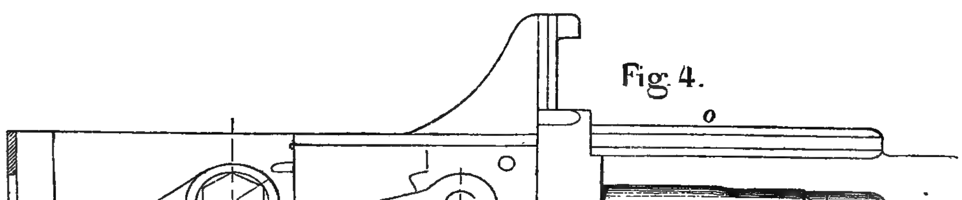


Fig. 4.



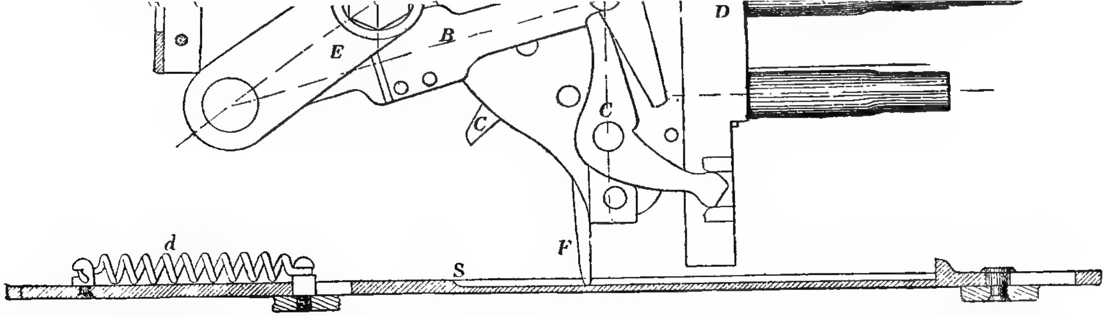
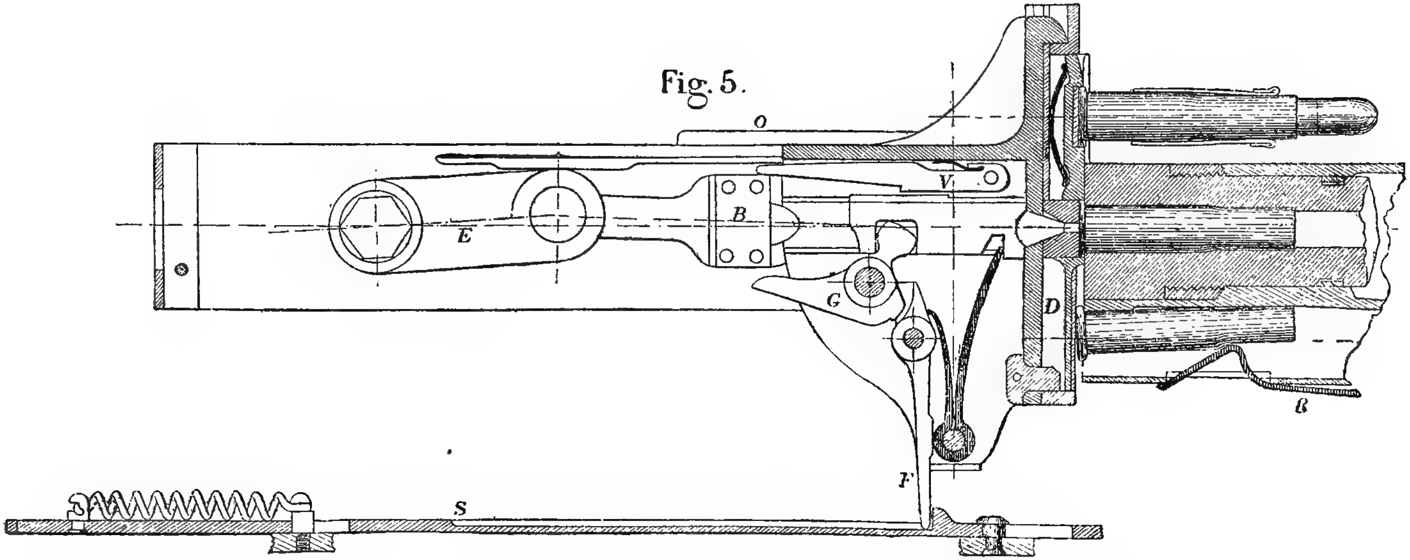
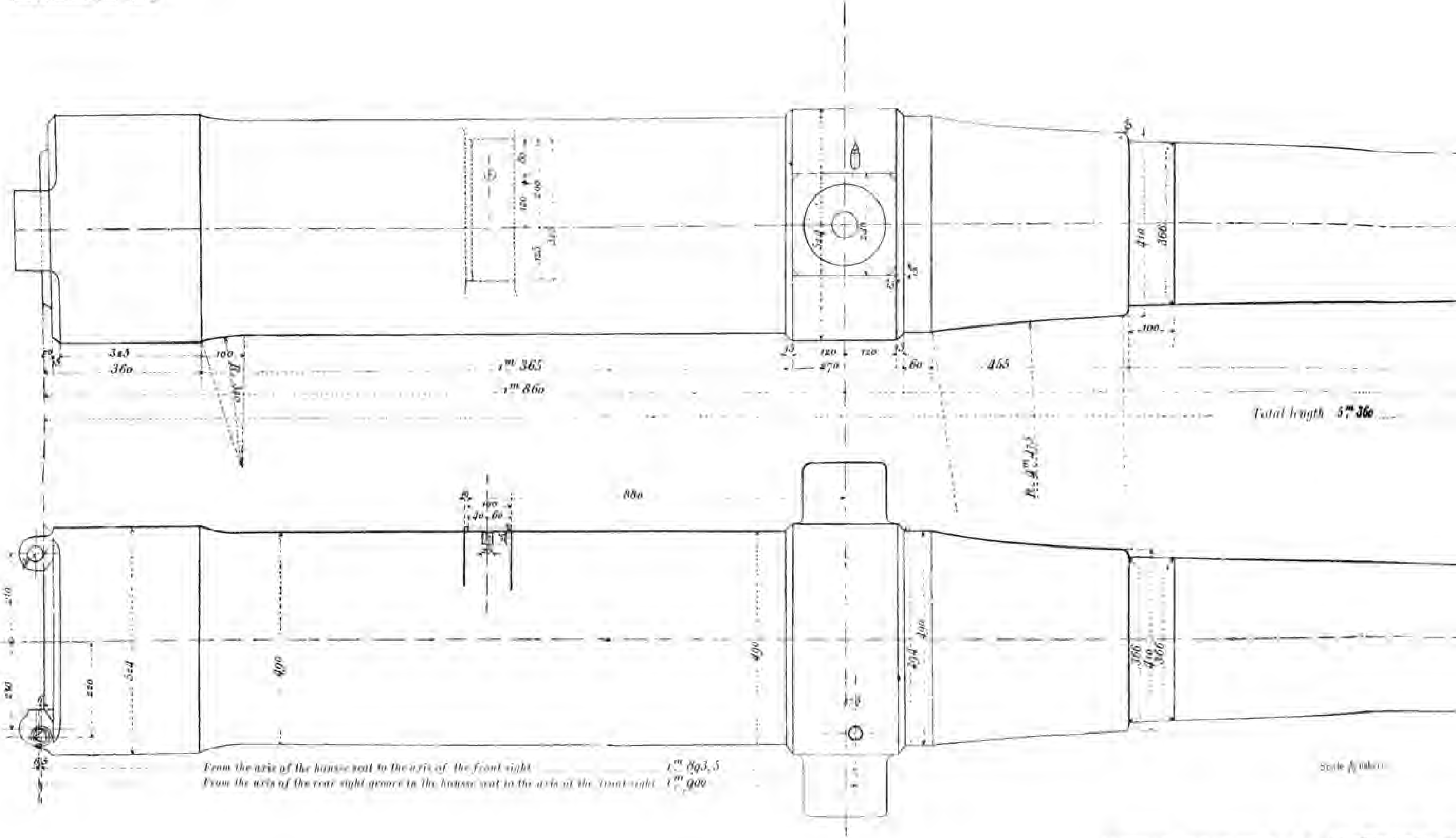


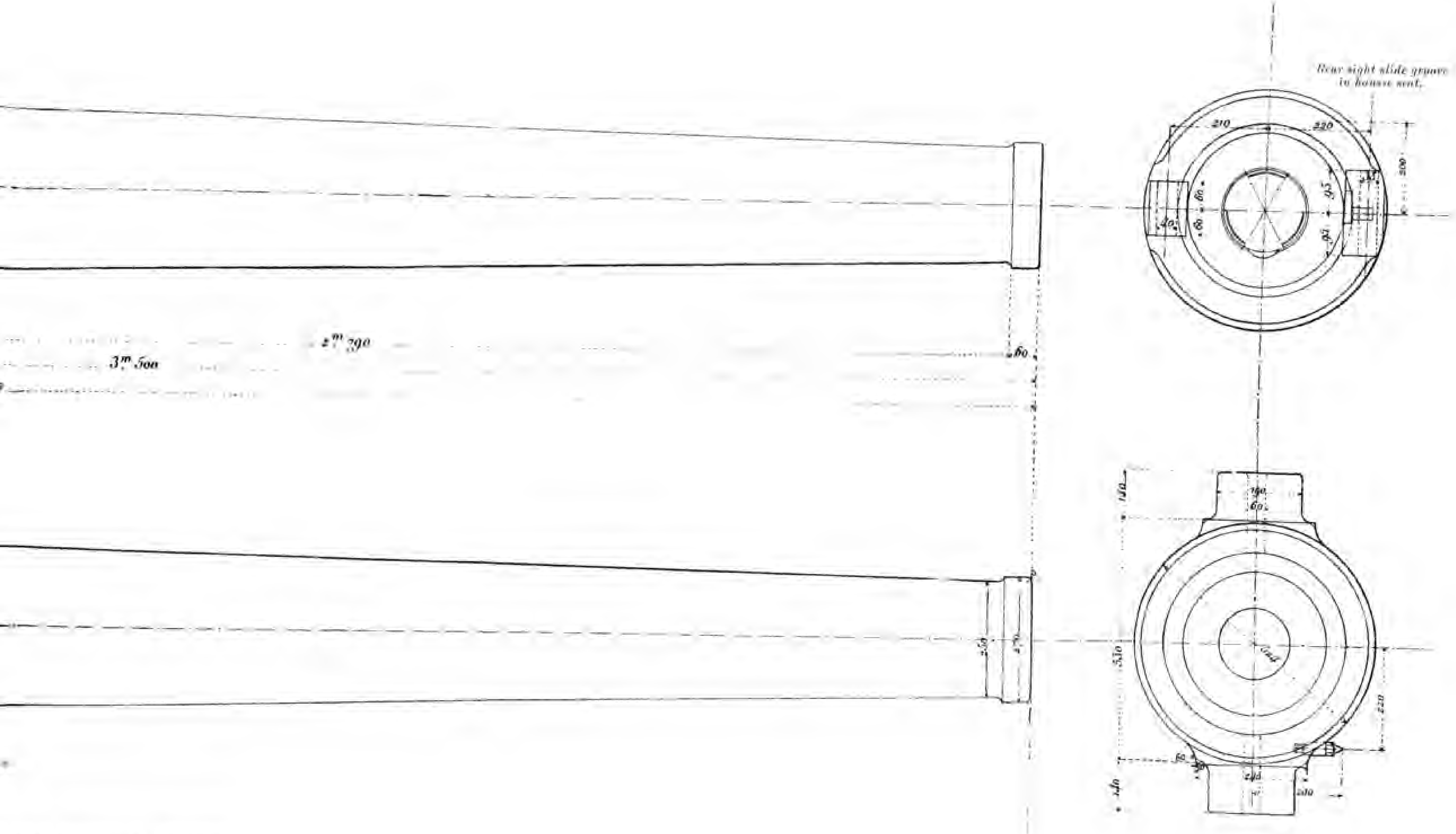
Fig. 5.



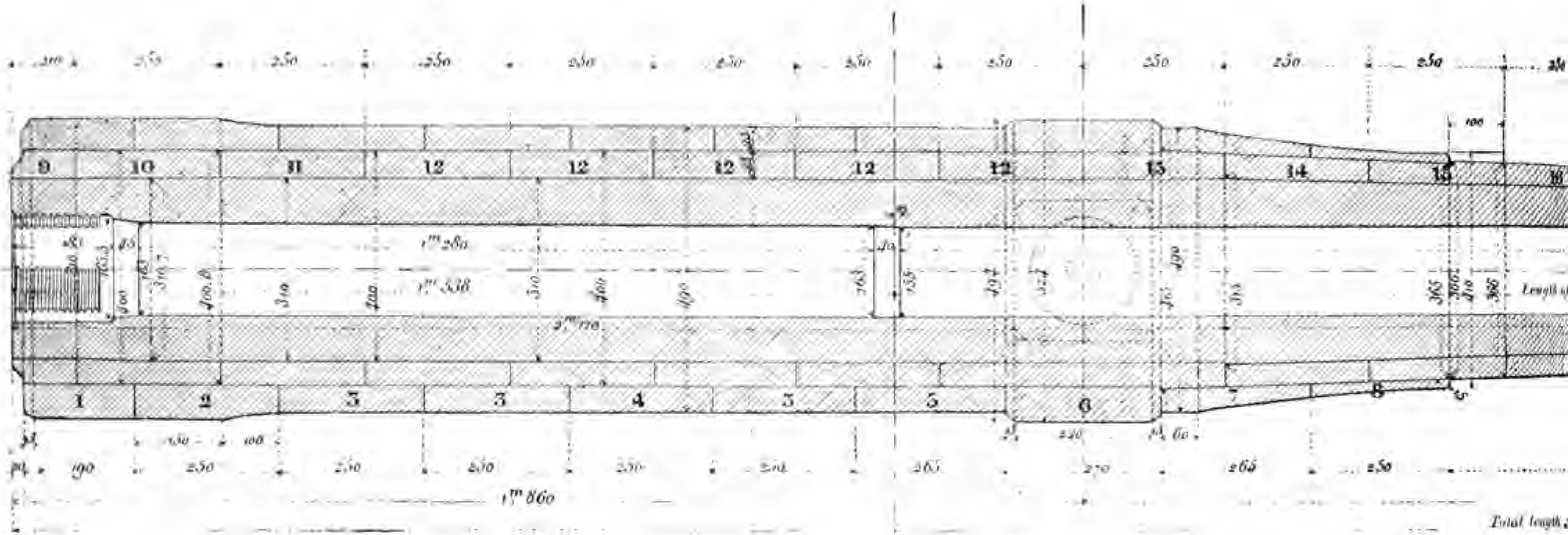
MAXIM AUTOMATIC MACHINE GUN.



155-MILLIMETER DE BANGE GUN, 35 CALIBERS LONG. DE



S LONG. DETAILS OF THE PIECE.

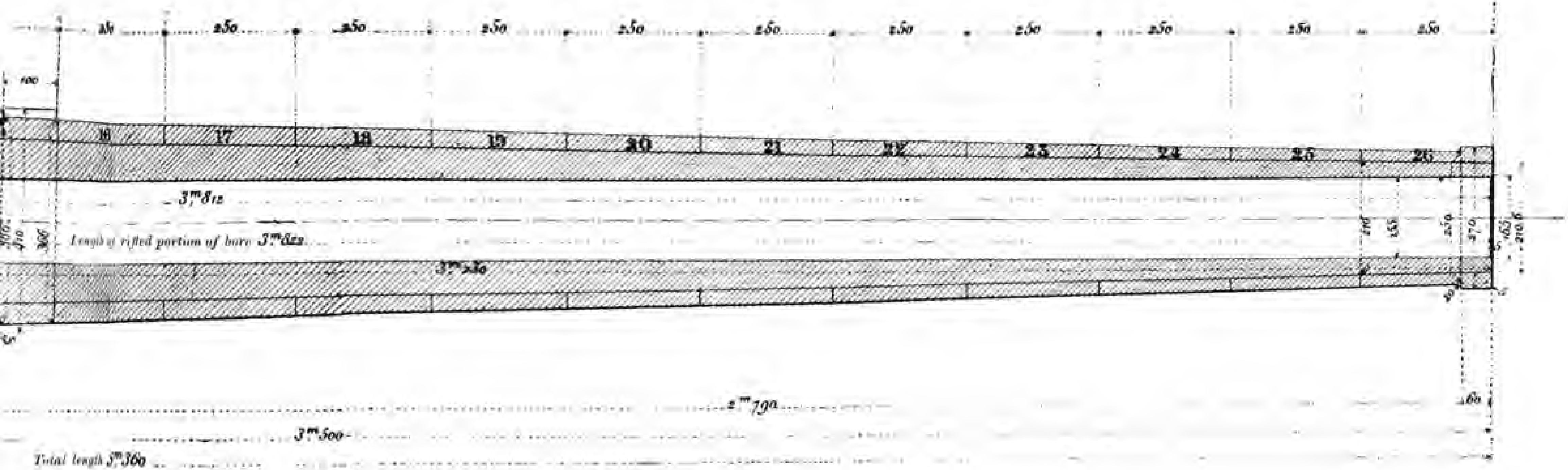


Total length

Scale

155-MILLIMETER DE BANGE GUN, 35 CALIB

The hooped portions are turned to the ... diameter of the hoops plus the following shrinkage: ... for hoops 14, 15, 16, 25, and 26, the shrinkage ... able to adjust th

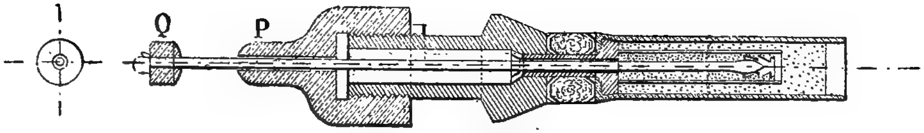


Scale 1/5 nature.

GUN, 35 CALIBERS LONG. DETAILS OF THE PIECE.

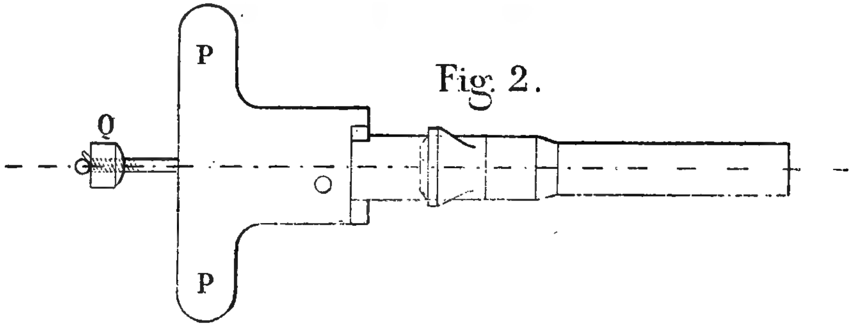
and 26, the shrinkage is variable and varies from 0.5mm at hoop 14 to 0.3mm at hoop 26. In hoops 7 and 8 the shrinkage is also variable, the limiting values being [illegible] and 0.4mm. After assembling do not finish turn the chase until the piece is completed, so as to be able to adjust the preponderance.

Fig. I.



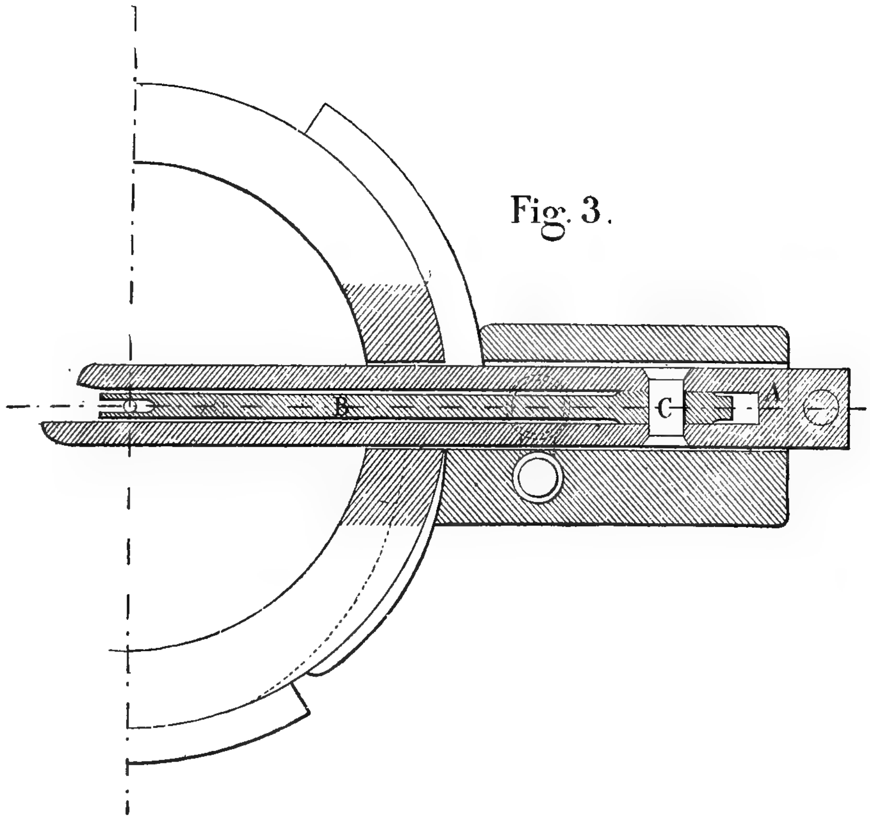
Vertical section of primer in firing position.

Fig. 2.



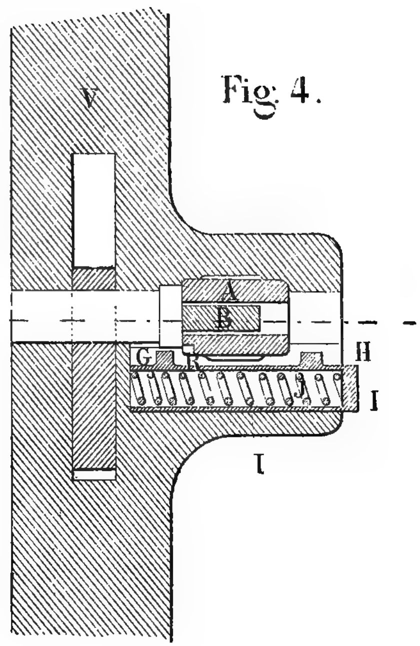
Plan of obturating primer.

Fig. 3.



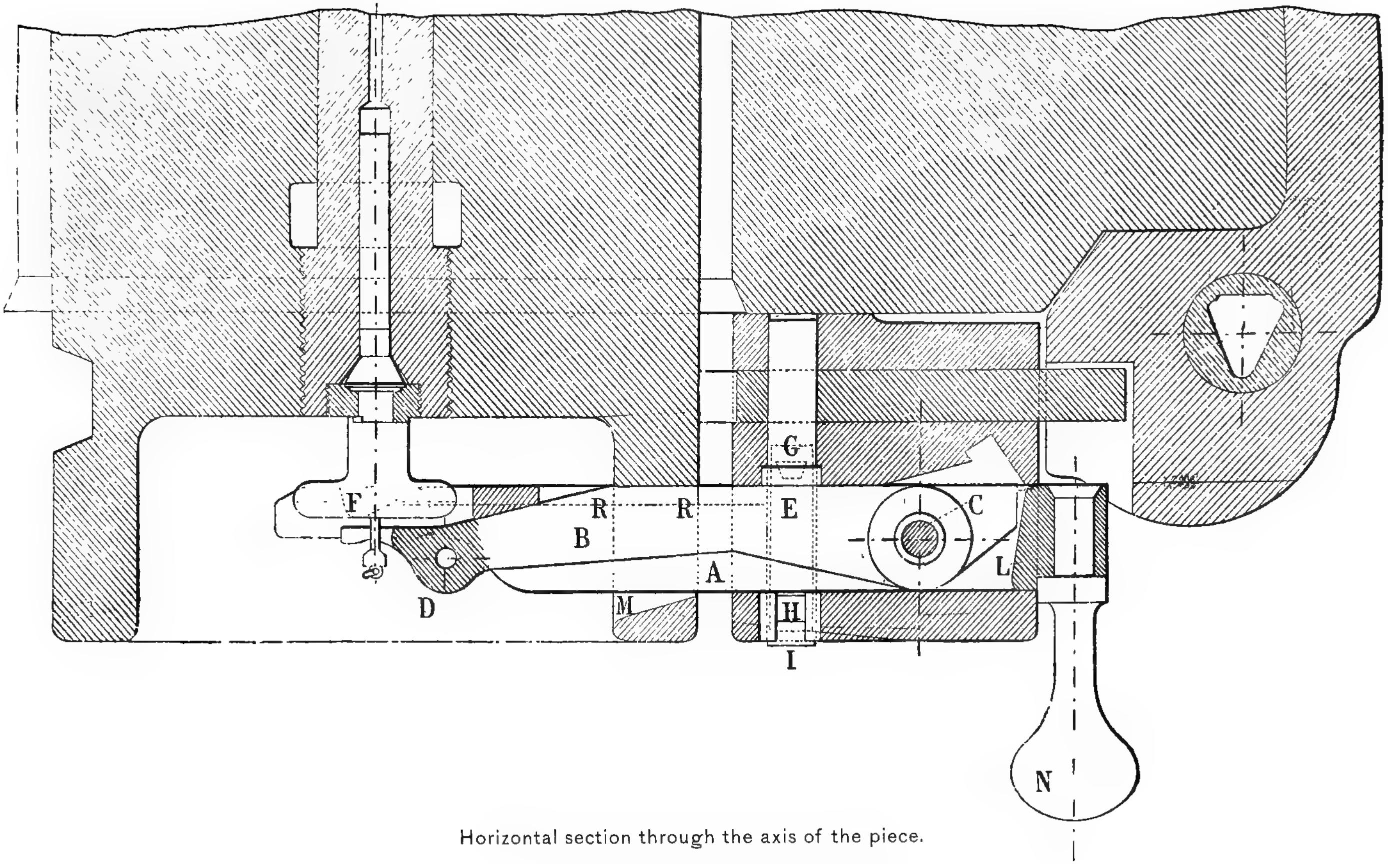
Rear view, showing the safety apparatus.

Fig. 4.



Vertical section through the axis of the piece.

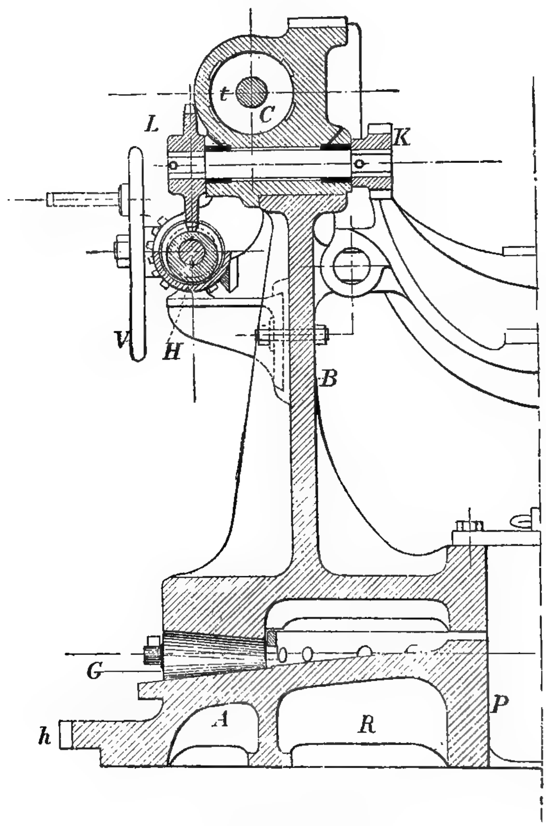
Fig. 3.



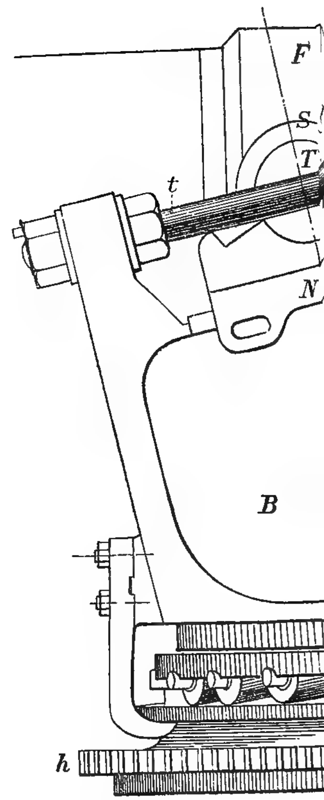
Horizontal section through the axis of the piece.

DE BANGE OBTURATING PRIMER.

Fig. 2.

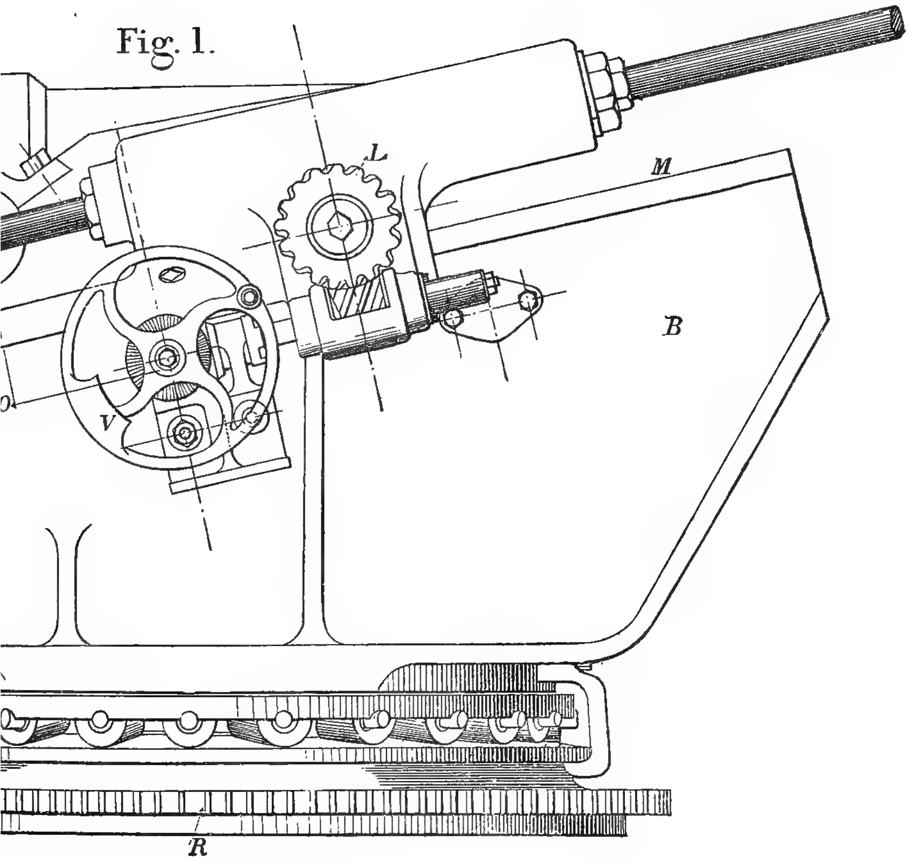


Transverse section.



SEACOAST CARRIAGE FOR 15

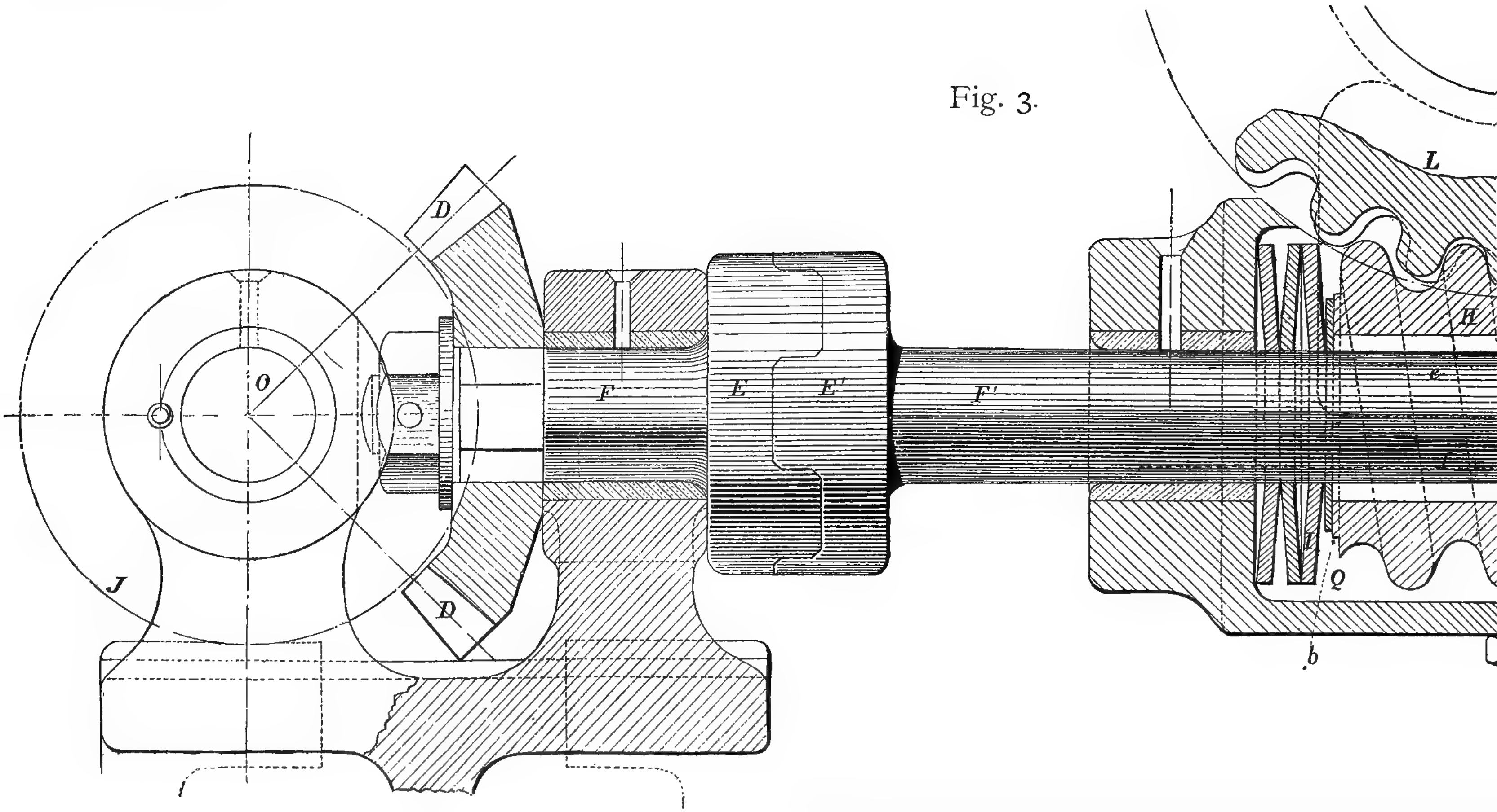
Fig. 1.



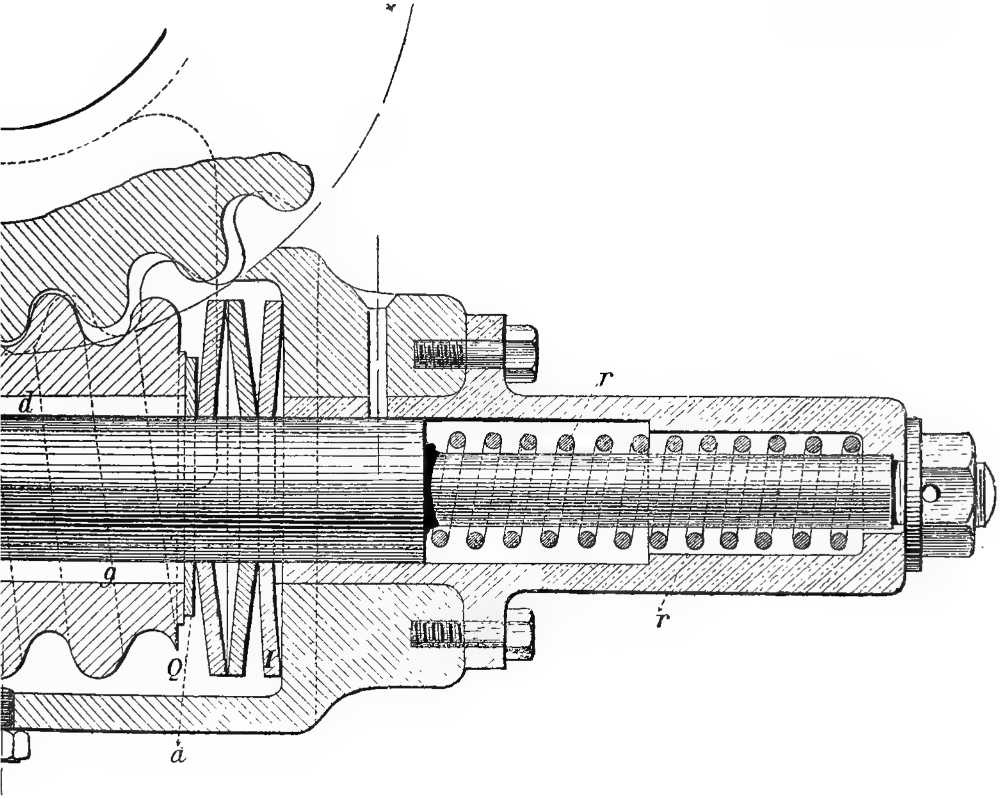
General view.

ILLIMETER DE BANGE GUN.

Fig. 3.

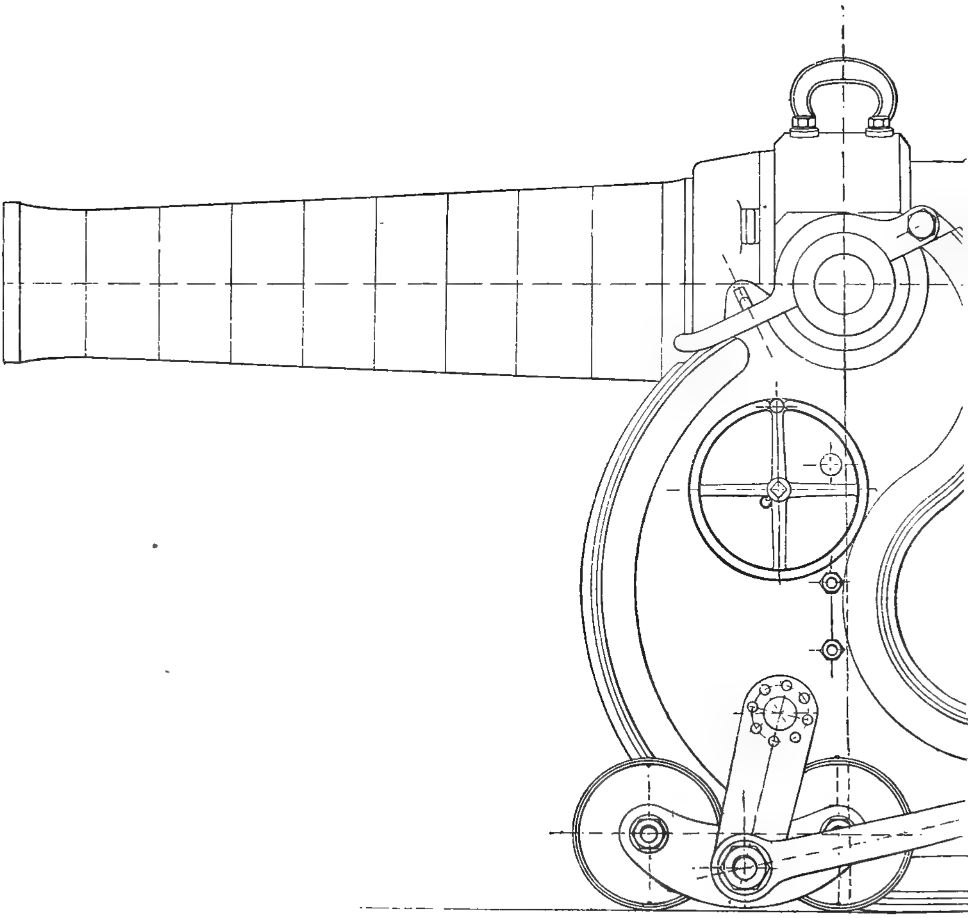


CLUTCH AND GEAR OF SEACOAST CARRIAGE FOR 155-MILLIMETER DE



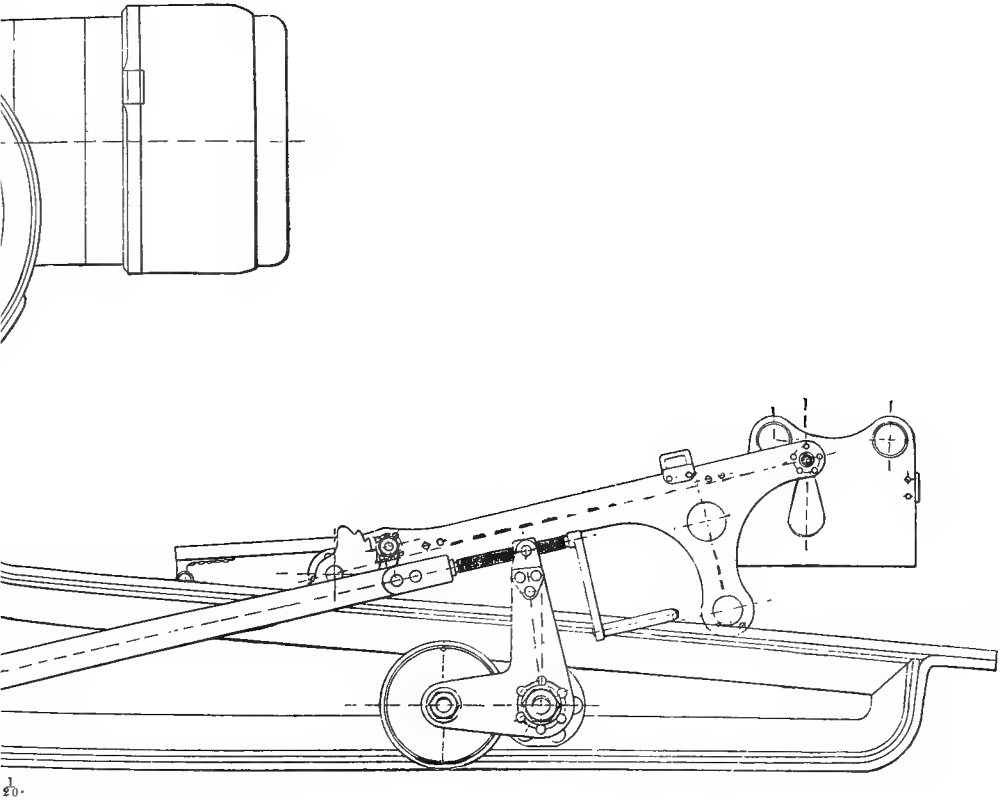
BANGE GUN.

General view of carriage.



Scale

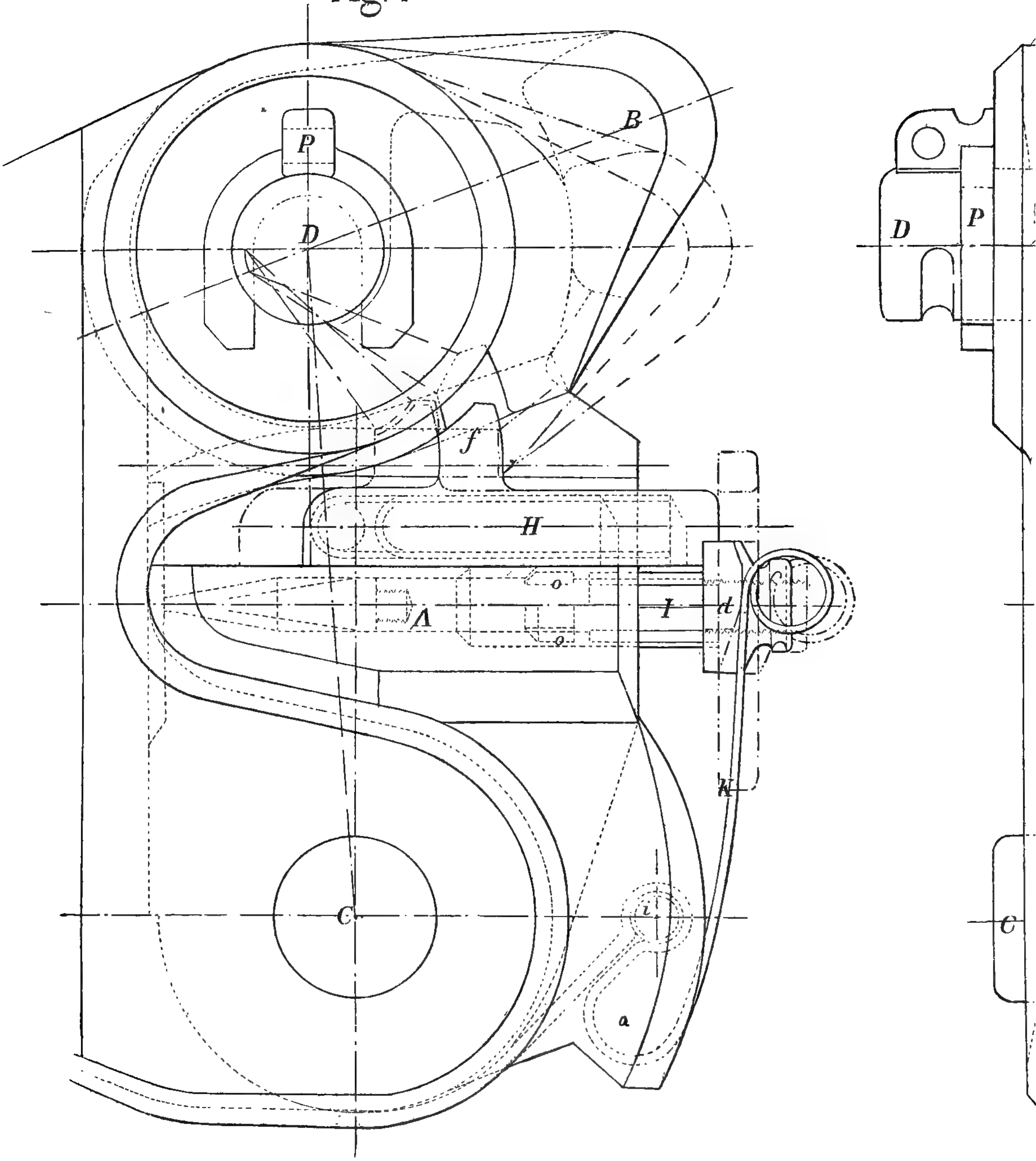
270-MILLIMETER MORTAR CARRIAGE



$\frac{1}{20}$.

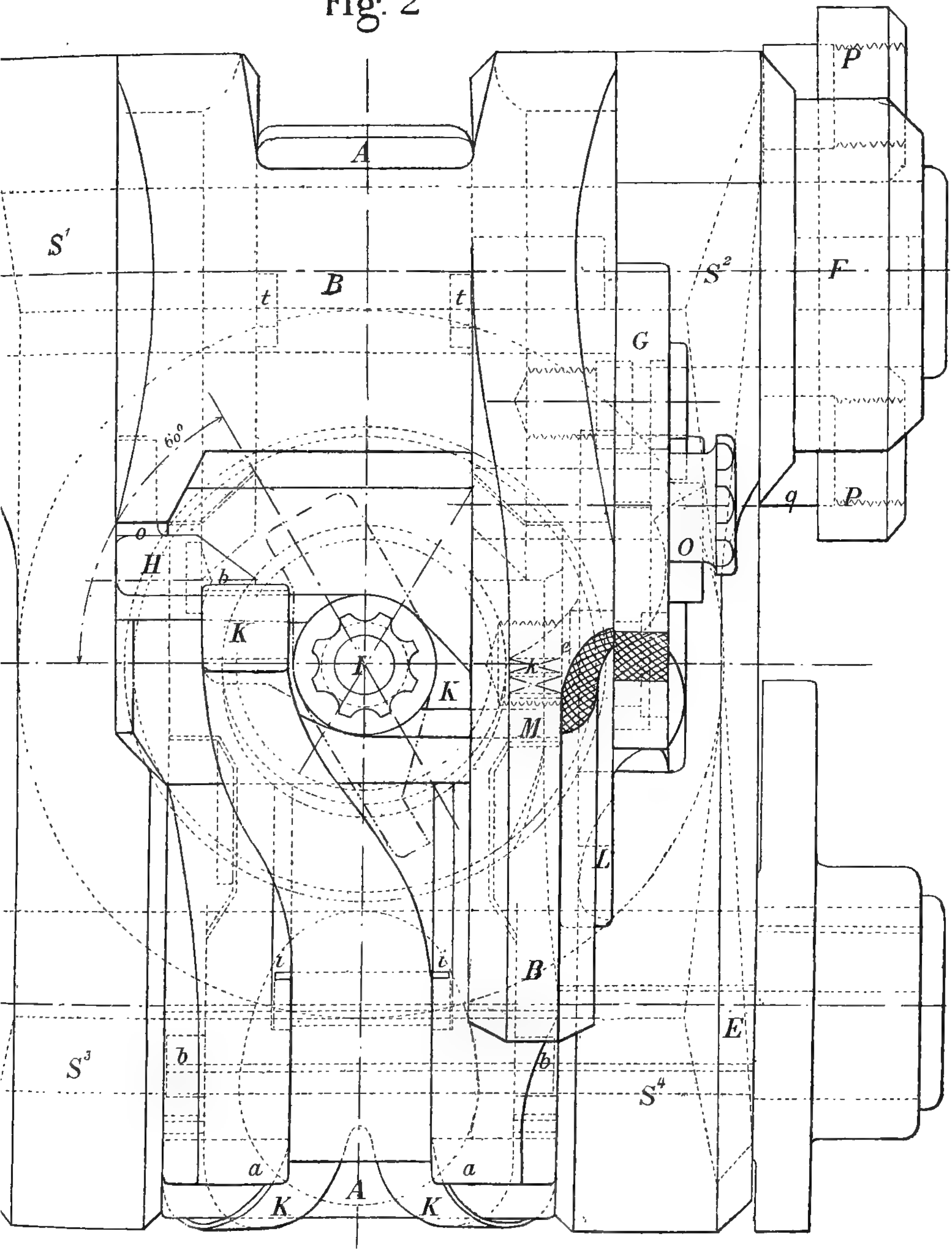
COLONEL DE BANGE'S SYSTEM).

Fig. 1



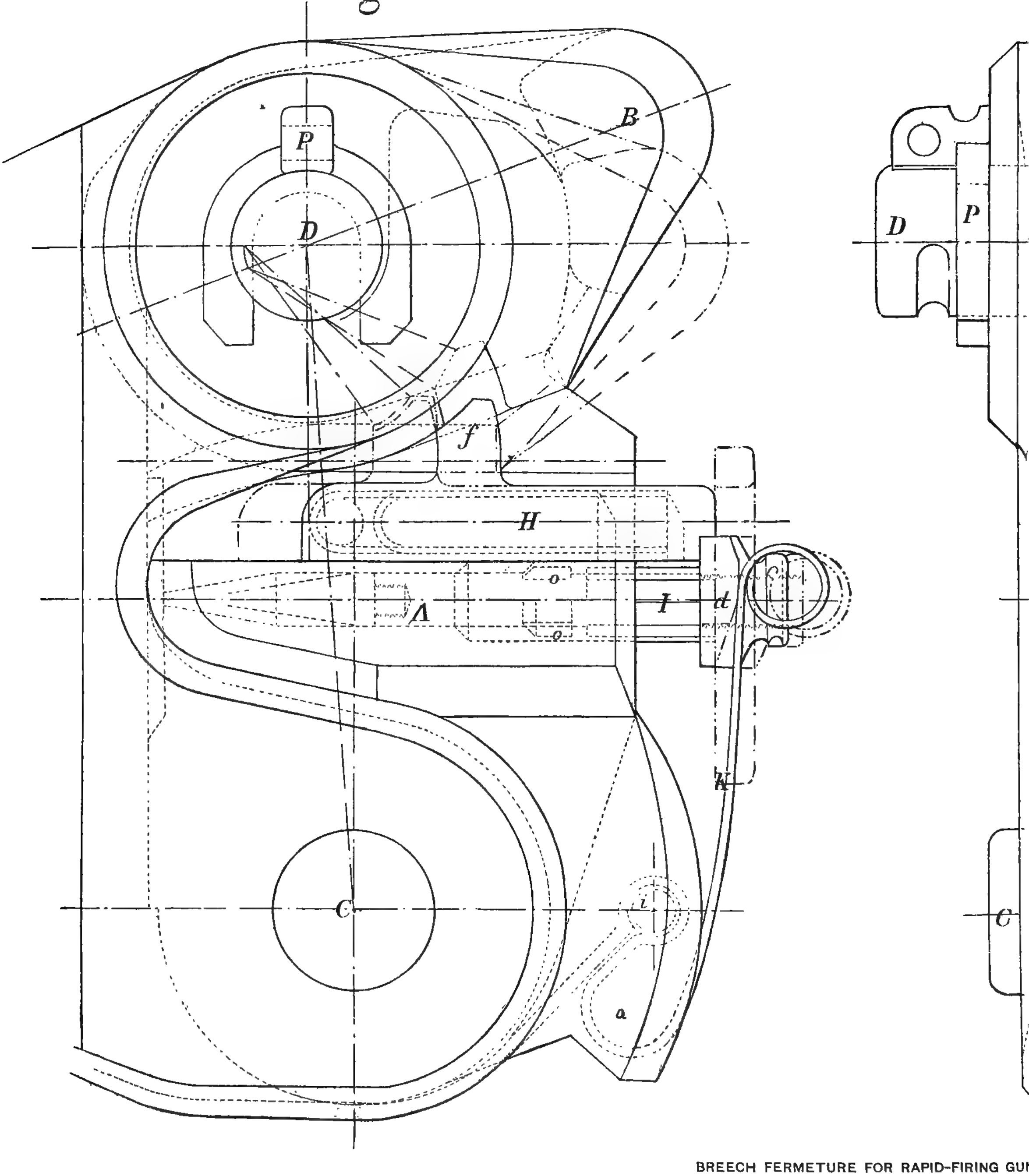
BREECH FERMETURE FOR RAPID-FIRING GUN

Fig. 2



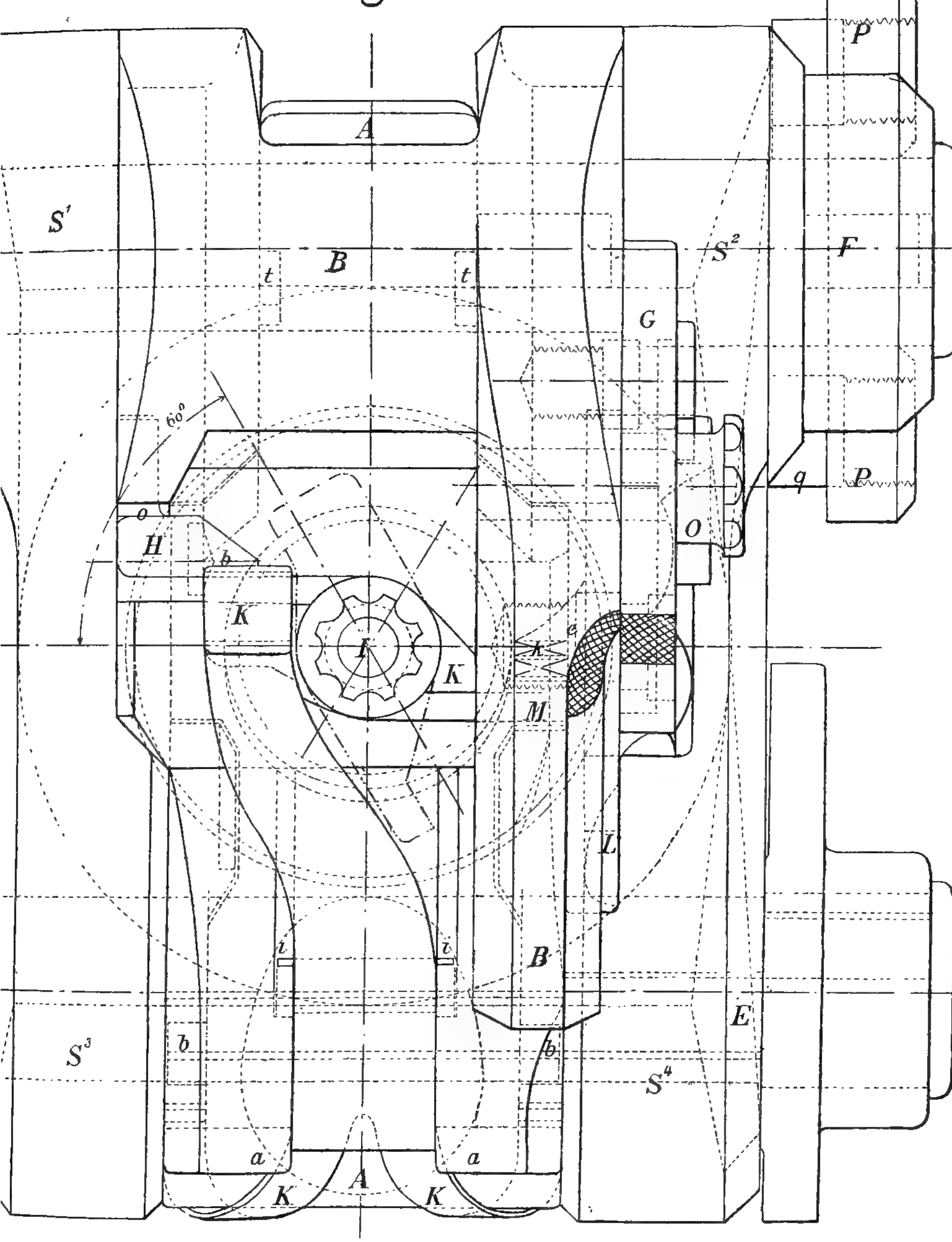
ENGSTRÖM'S SYSTEM.

Fig. 1

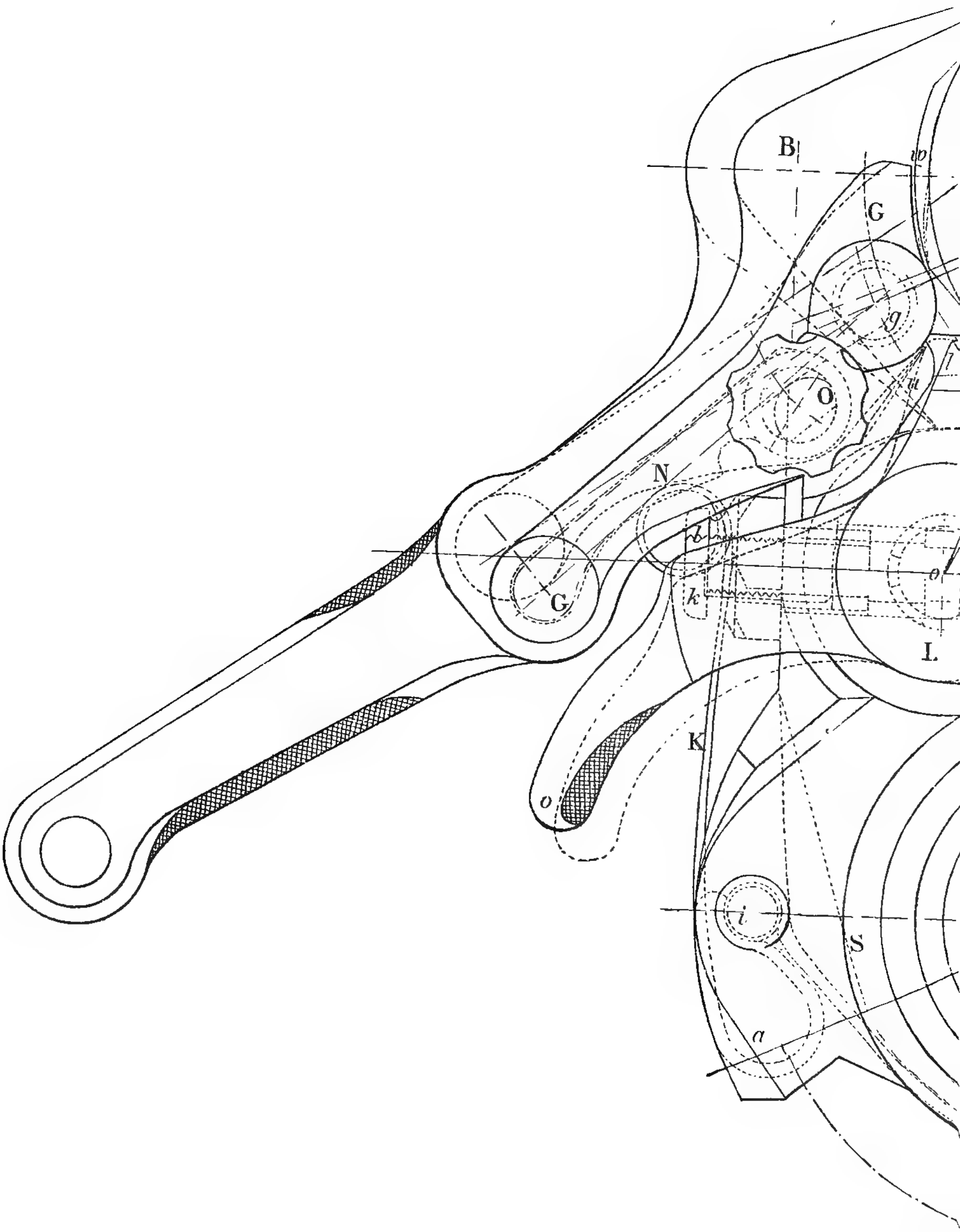


BREECH FERMETURE FOR RAPID-FIRING GUN

Fig. 2

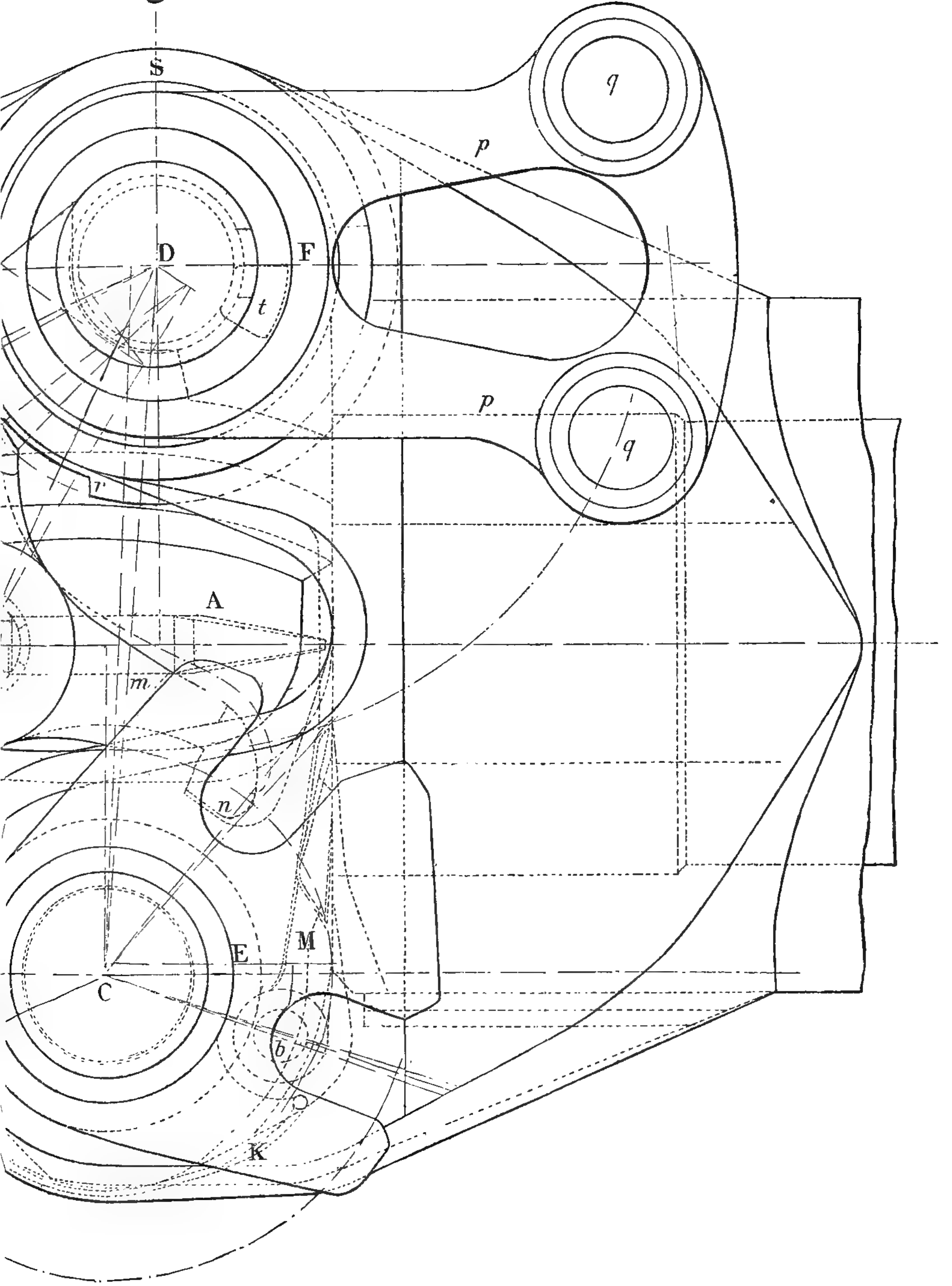


ENGSTRÖM'S SYSTEM.

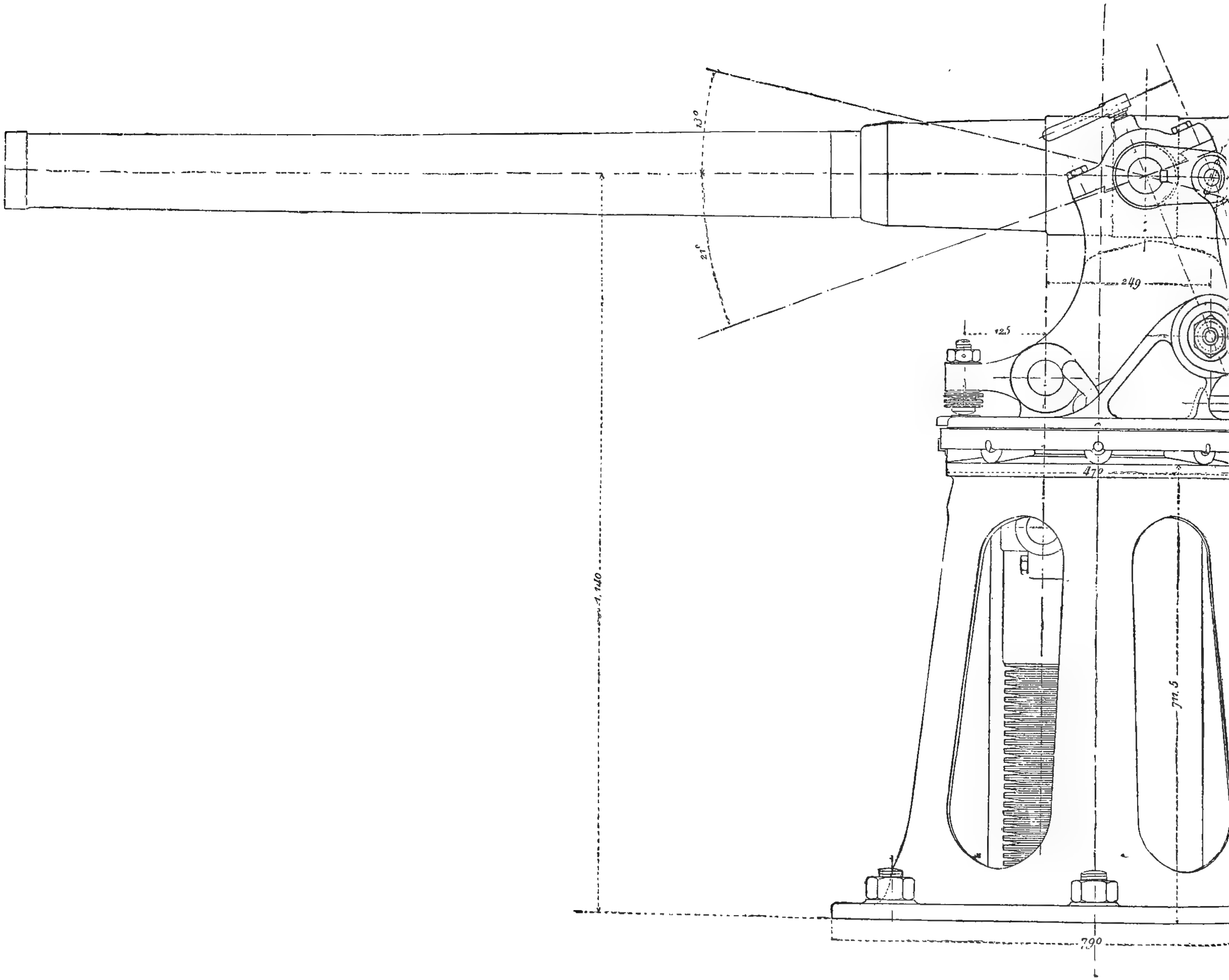


BREECH FERMETURE FOR RAPID-

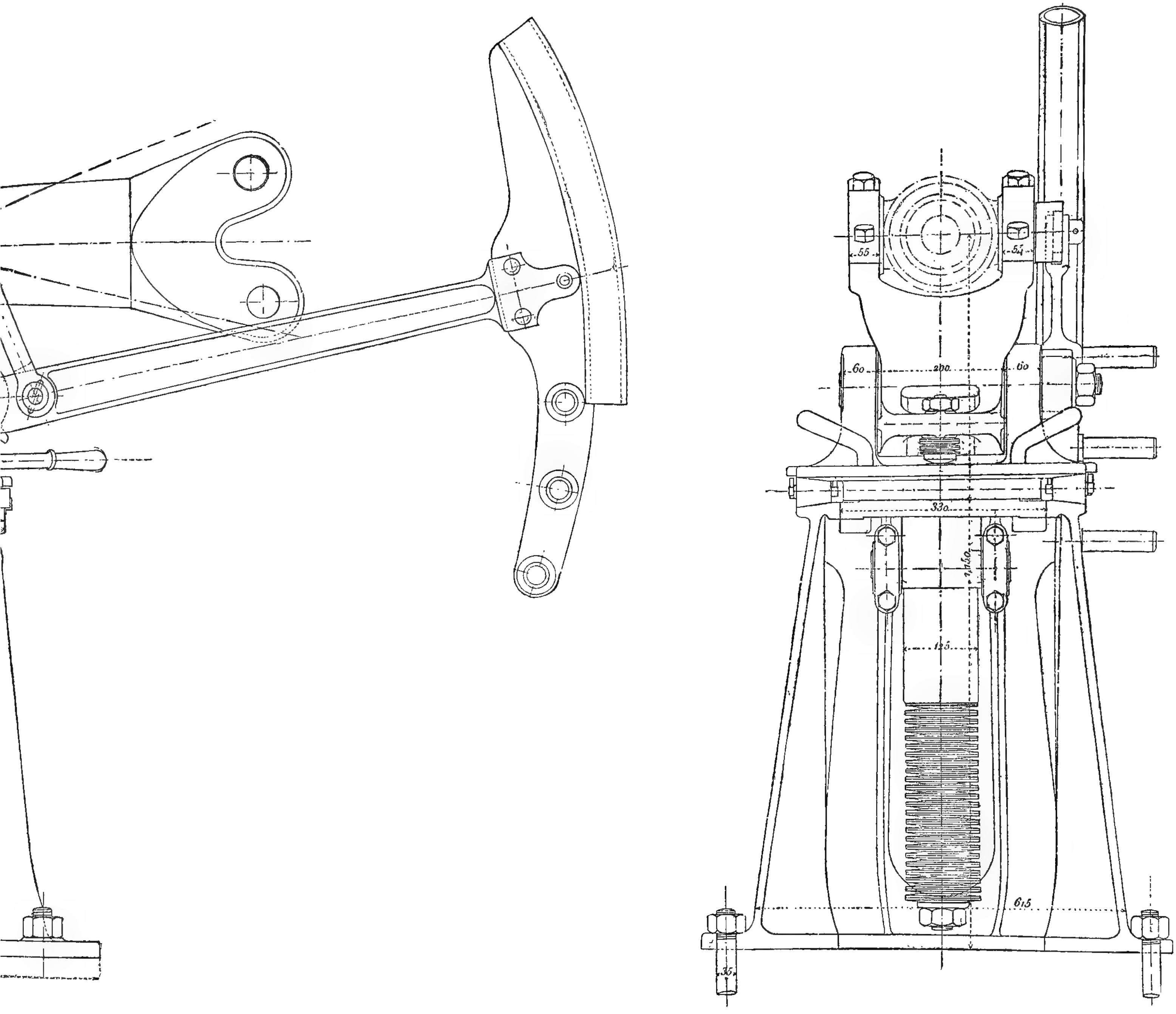
Fig. 3



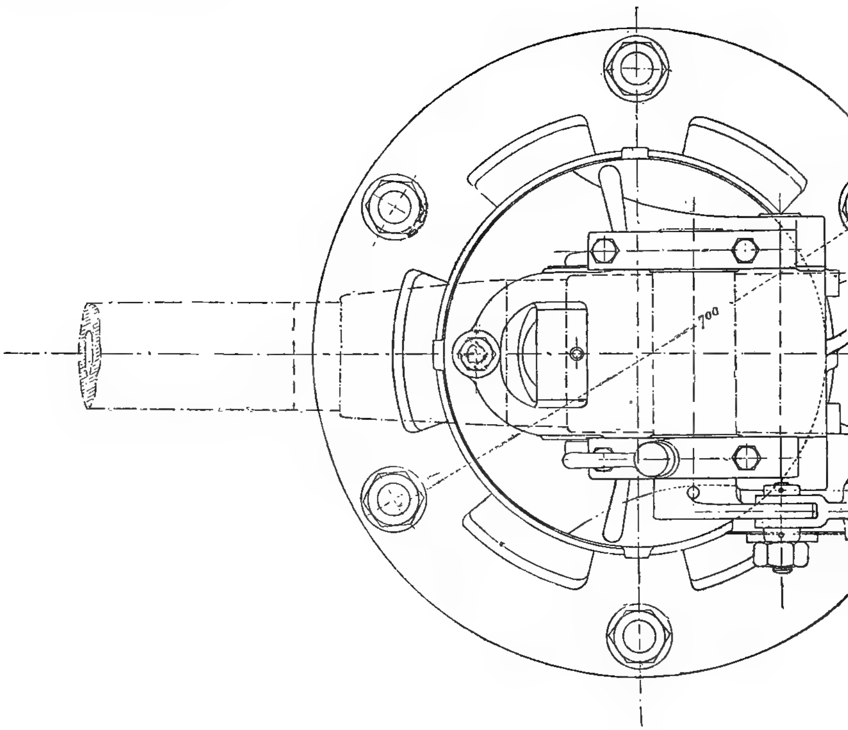
-FIRING GUN. ENGSTRÖM'S SYSTEM.



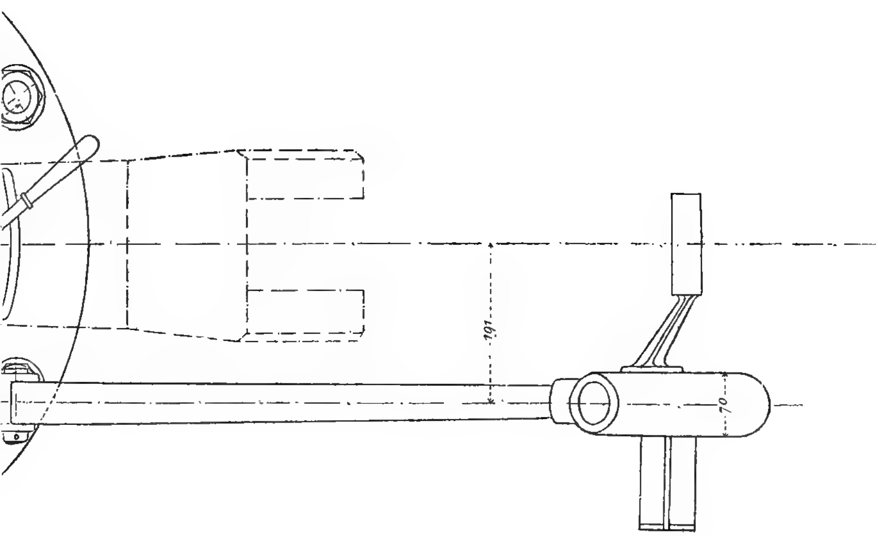
CARRIAGE WITH HYDRAULIC BRAKE FOR THE HEAVY 57-



ILLIMETER ENGSTRÖM RAPID-FIRING GUN. GENERAL VIEWS.

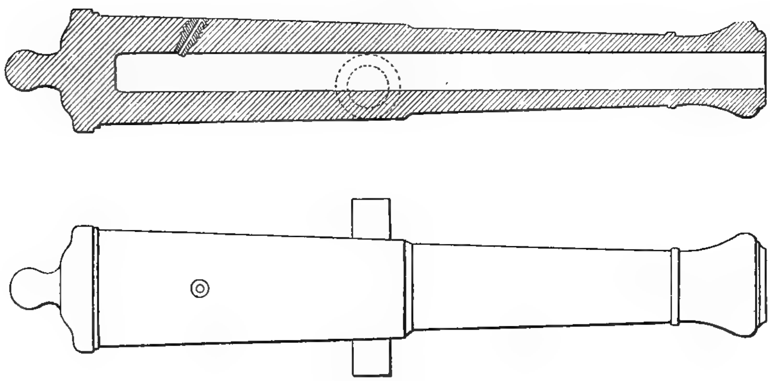


CARRIAGE WITH HYDRAULIC BRAKE FOR THE H

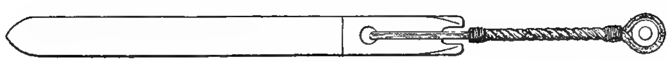


AVY 57-MILLIMETER ENGSTRÖM RAPID-FIRING GUN. PLAN.

Le Perrier.

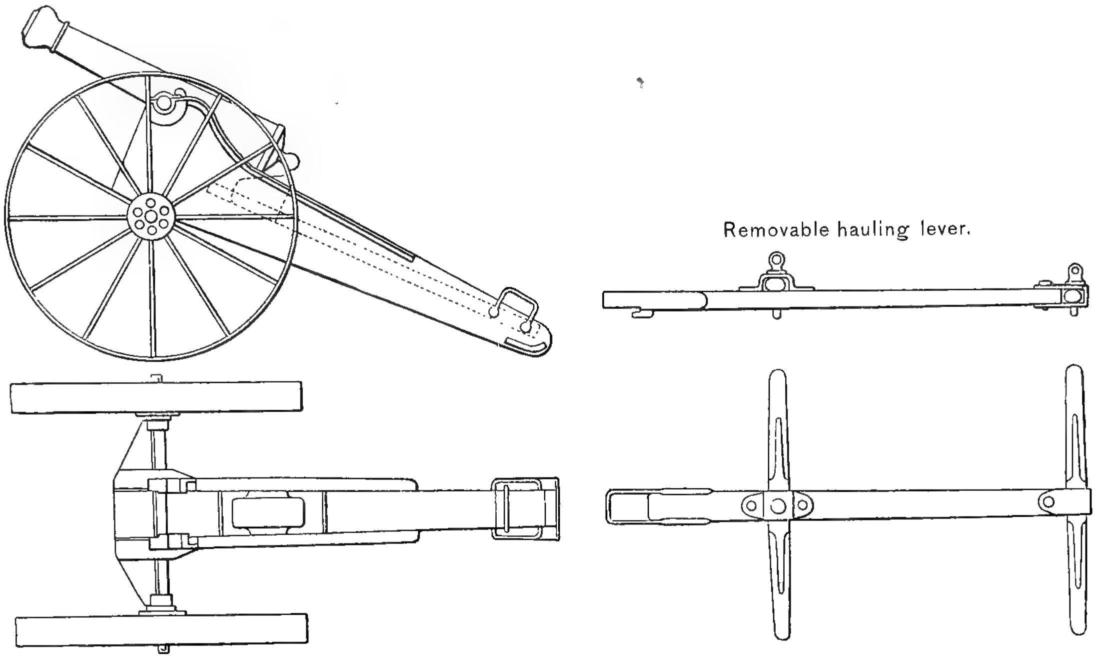


Projectile



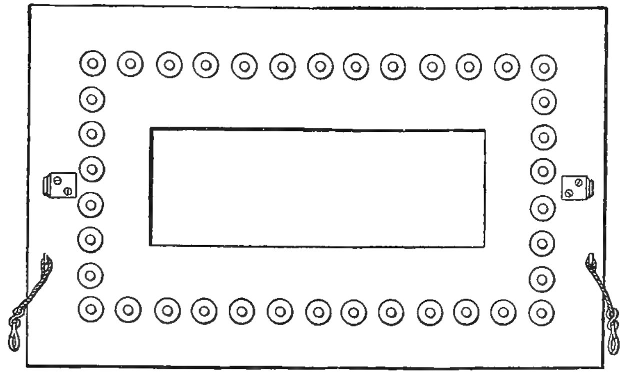
Scale $\frac{1}{10}$.

LIFE-SAVING GUN AND PROJECTILE.

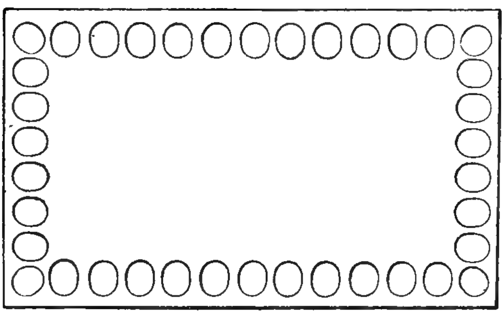


Scale $\frac{1}{25}$.

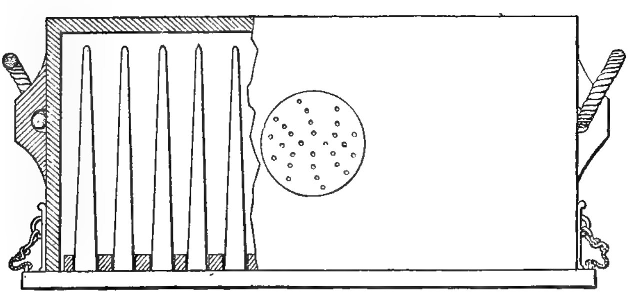
LIFE-SAVING APPARATUS. CARRIAGE FOR "LE PERRIER."



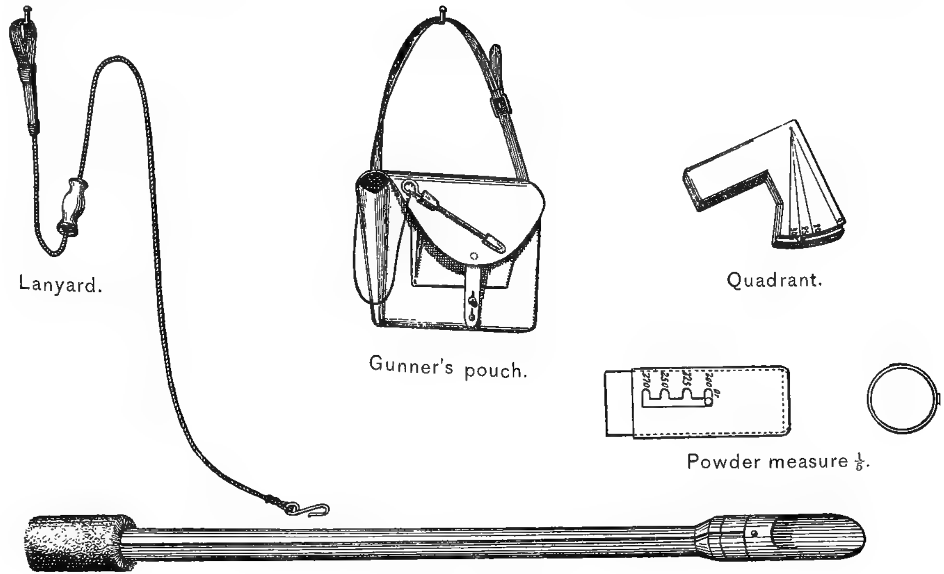
FRAME WITH FAKING PINS.



FALSE BOTTOM.



FAKING BOX.



Lanyard.

Gunner's pouch.

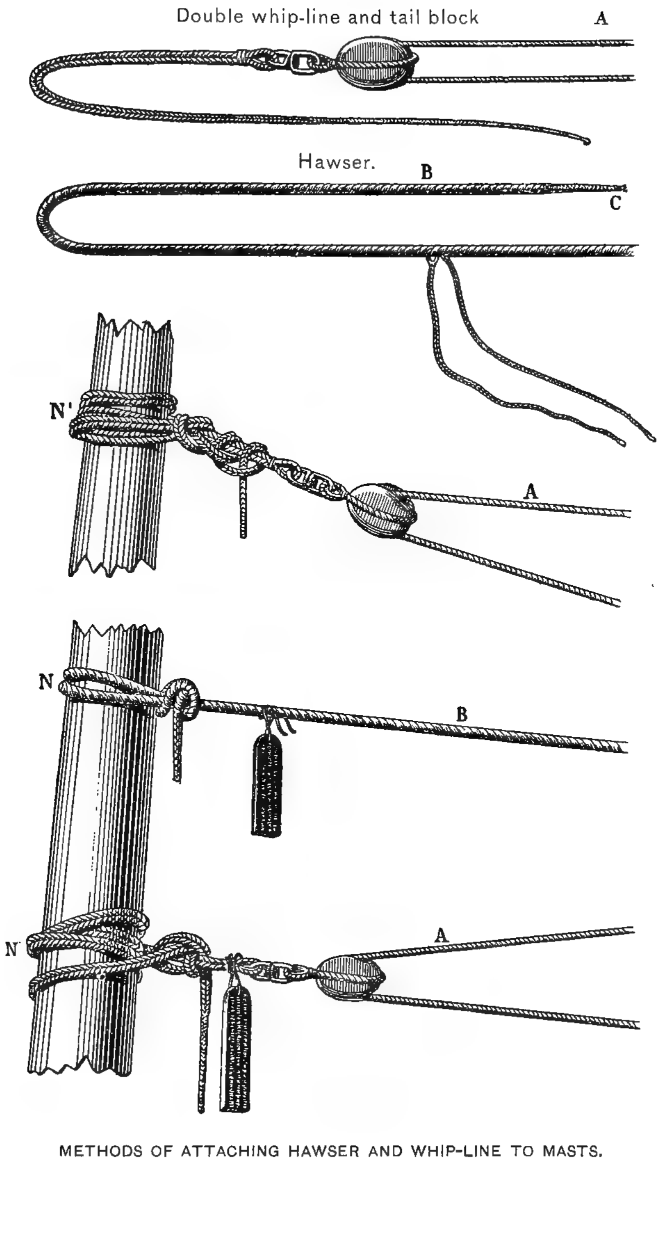
Quadrant.

Powder measure $\frac{1}{5}$.

Sponge and Ladle.

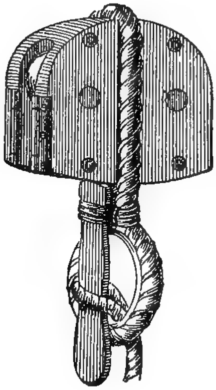
Scale $\frac{1}{10}$.

LIFE-SAVING APPARATUS.

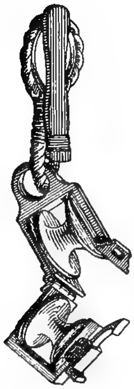


METHODS OF ATTACHING HAWSER AND WHIP-LINE TO MASTS.

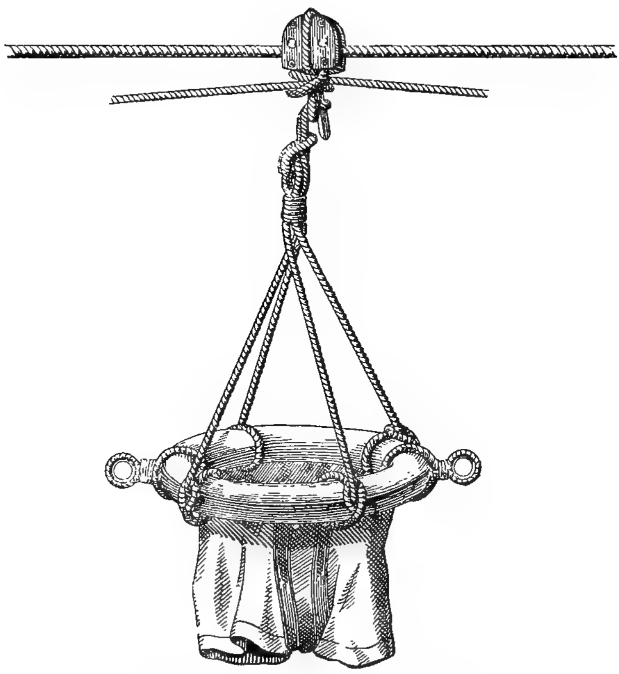
No. 1.



No. 2.

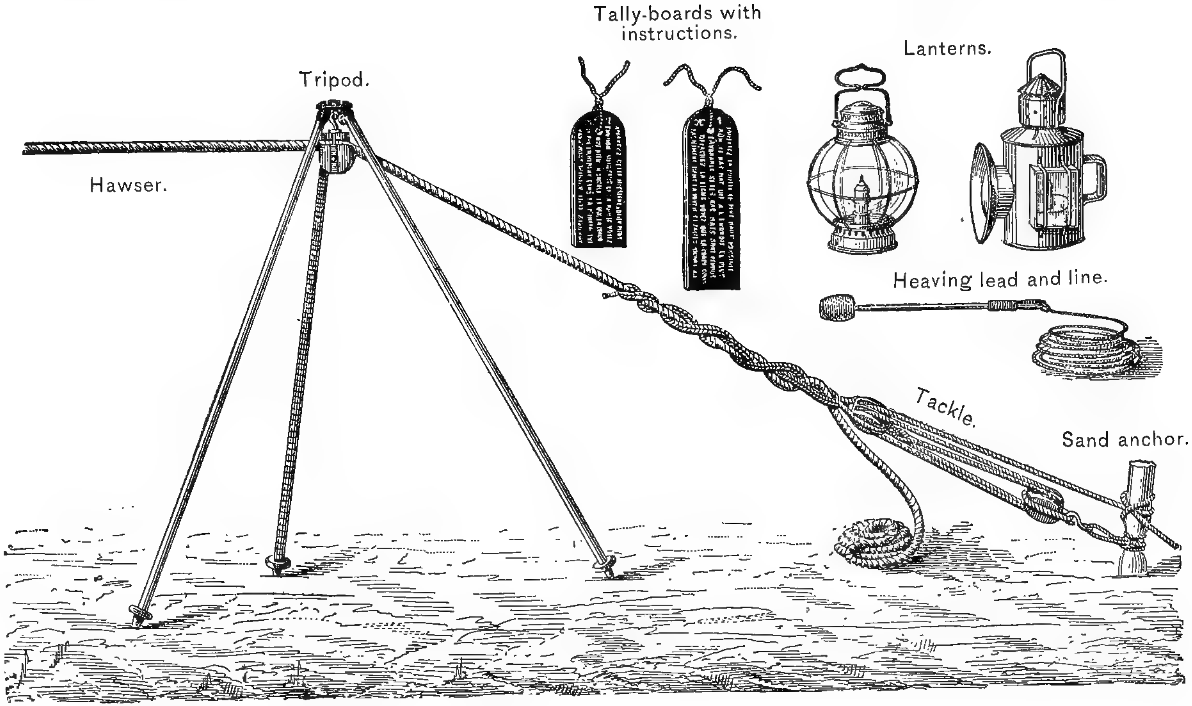


Sliding pulleys.



Breeches buoy suspended from hawser.

LIFE-SAVING APPARATUS.



LIFE-SAVING APPARATUS.

Fig. 1 bis.

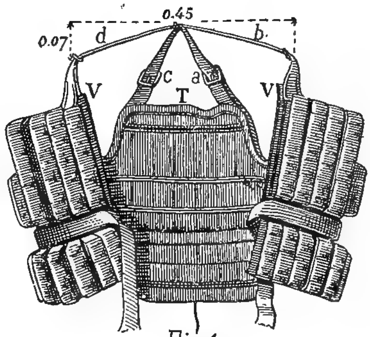


Fig. 1.

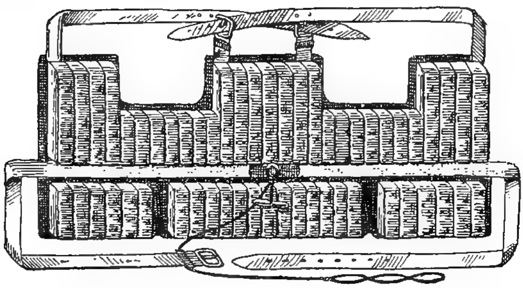


Fig. 2

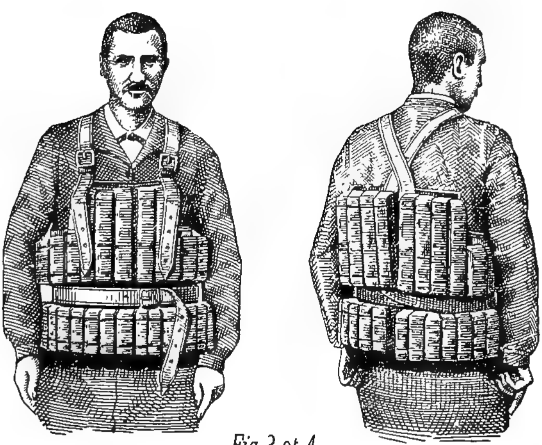
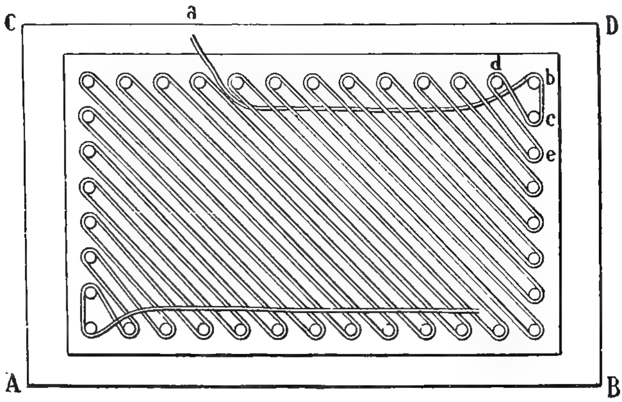
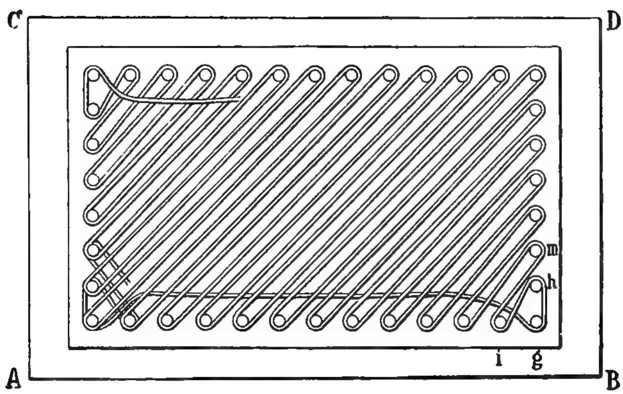


Fig. 3 et 4.

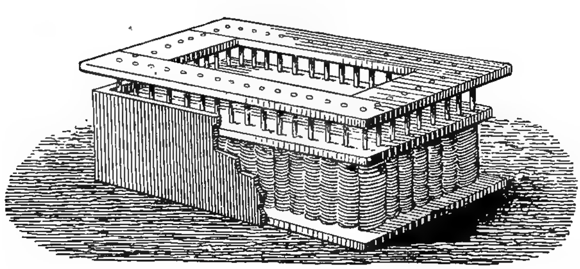
CORK LIFE BELTS. METHOD OF WEARING.



First tier of faking.



Second tier of faking.



Preparation of line for firing.

FAKING BOX AND SHOT-LINE.

Fig. 1 Plan vertical

Head wind.

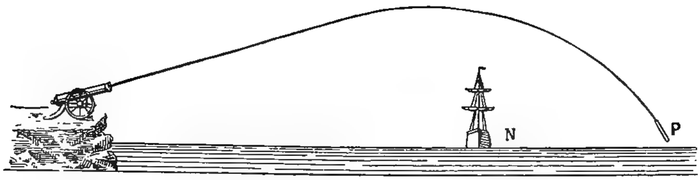


Fig. 2. Plan horizontal

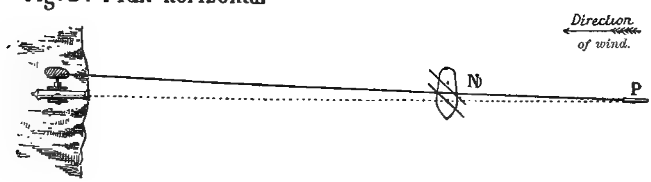


Fig. 3. Plan vertical

Cross wind.

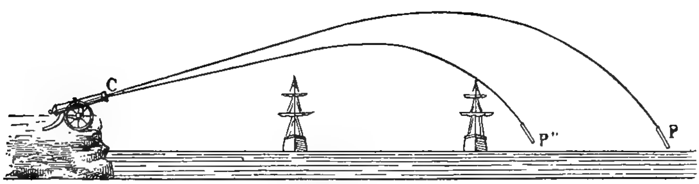
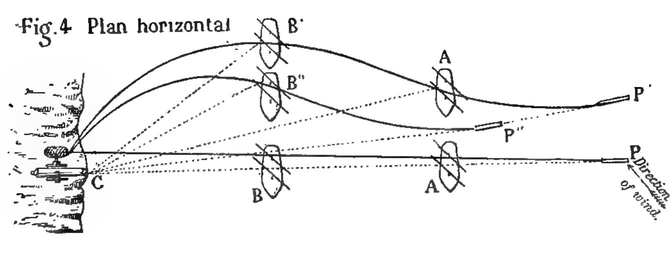


Fig. 4 Plan horizontal



LIFE-SAVING APPARATUS. EFFECT OF WIND ON THE SHOT-LINE.

Fig. 1.

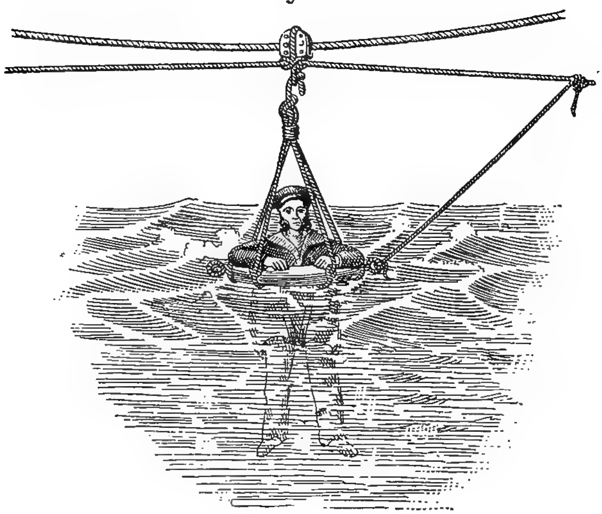
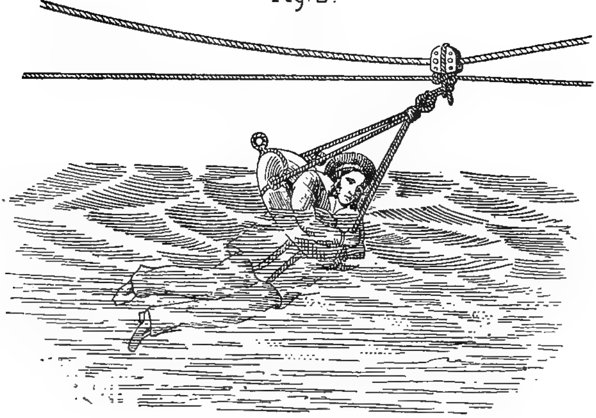


Fig. 2.



METHODS OF ATTACHING BREECHES BUOY.

Fig. 1.

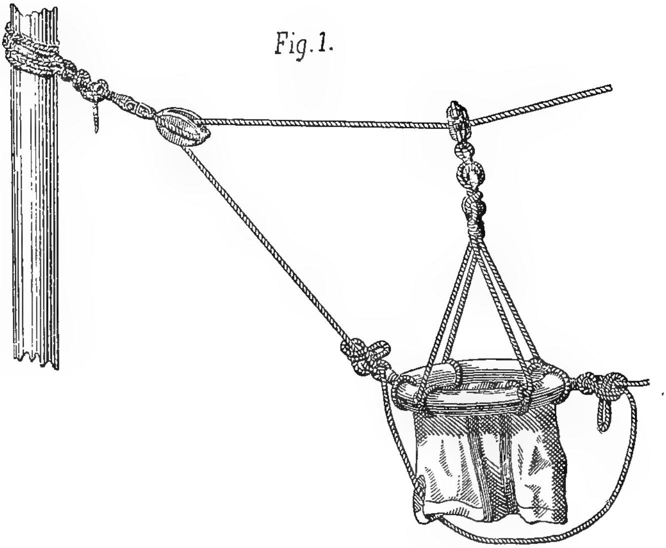
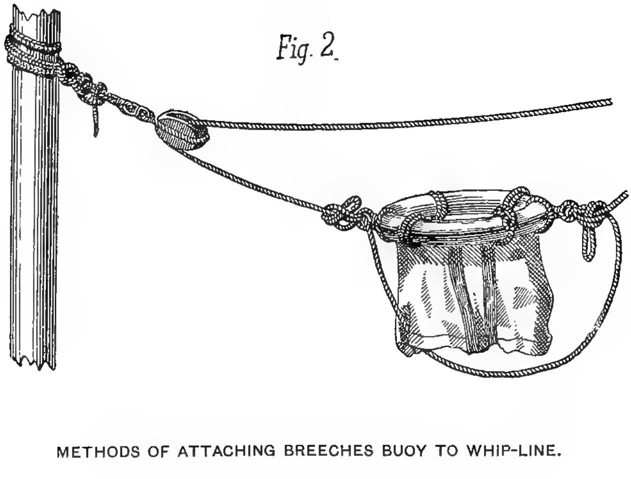
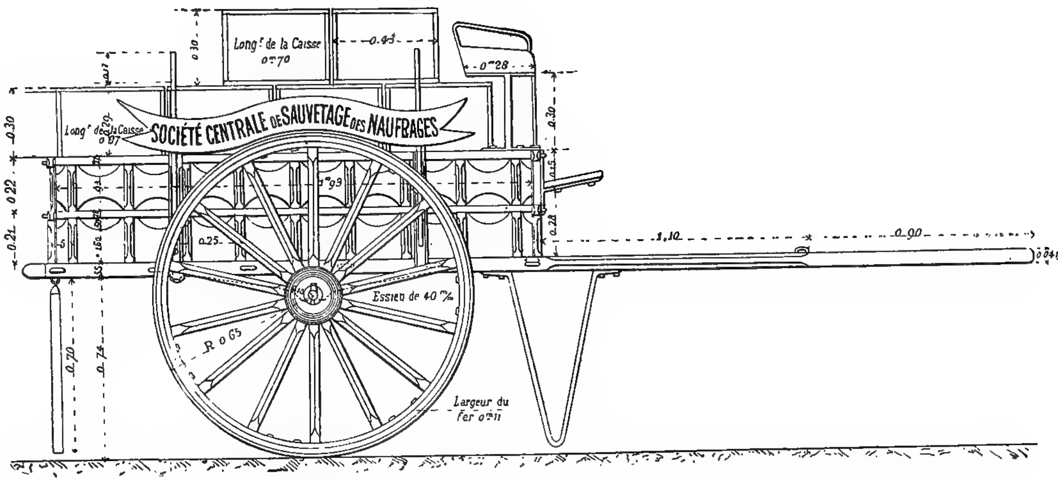


Fig. 2.



METHODS OF ATTACHING BREECHES BUOY TO WHIP-LINE.

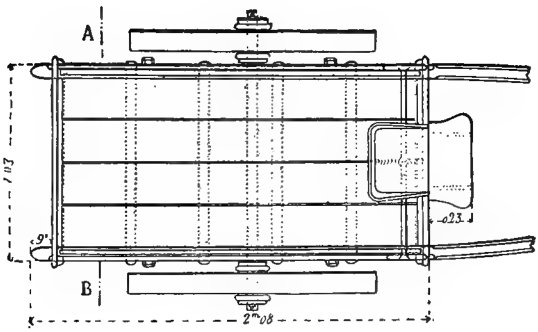
Side elevation.



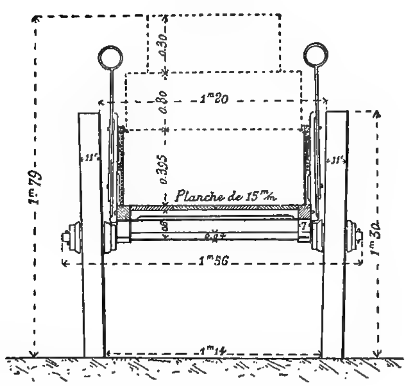
Scale $\frac{1}{30}$.

APPARATUS CART.

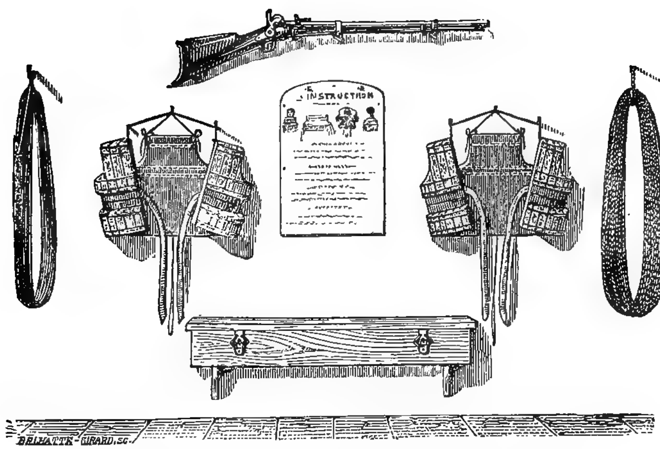
Plan.



End elevation.

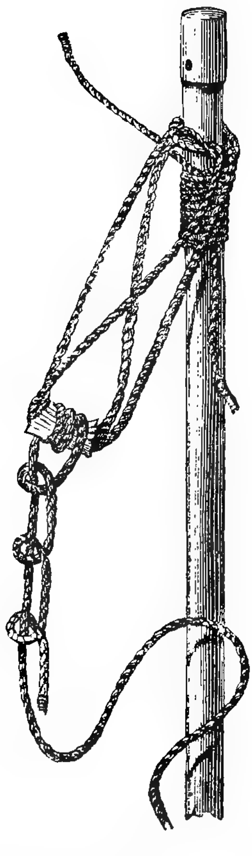


APPARATUS CART.



DISPOSITION OF APPARATUS ON WALL OF LIFE-SAVING STATION.

LINE-THROWING SMALL ARM.



SLIDING-KNOT USED TO ATTACH THE SHOT-LINE TO THE ARROW FIRED FROM THE PIECE.

PART II.

SEVENTH GROUP - - ALIMENTARY PRODUCTS.
NINTH GROUP - - HORTICULTURE.

EDITED BY

A. HOWARD CLARK,

U. S. Expert Commissioner for the Seventh Group.

SEVENTH GROUP.

ALIMENTARY PRODUCTS.

[*EXTRACT FROM THE OFFICIAL CLASSIFICATION.*]

SEVENTH GROUP.—ALIMENTARY PRODUCTS.

CLASS 67. Cereals: Farinaceous products with their derivatives.
68. Products of the bakery and pastry shop.
69. Fat substances used for food, milk products, and eggs.
70. Meats and fishes.
71. Vegetables and fruits.*
72. Condiments and stimulants; sugar, and products of confectionery.
73. Fermented drinks.

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*The report on vegetables and fruits will be found under Group VIII, by Prof. C. V. Riley.

REPORT

ON

ALIMENTARY PRODUCTS.

BY

A. HOWARD CLARK,

UNITED STATES EXPERT COMMISSIONER FOR THE SEVENTH GROUP.

DIVISION OF REPORT.

ALIMENTARY PRODUCTS.

By A. HOWARD CLARK, Expert Commissioner.

INTRODUCTION.

The exhibits of articles of food in the seventh group included all alimentary substances; that is, every material supplying to man the elements necessary to renew the tissues and to supply animal heat. The range of these substances is so wide, both in the animal and vegetable kingdoms, that it will not be attempted in this report even to enumerate the thousand or more varieties of food consumed by the inhabitants of the countries represented at the Exposition.

The foods of nearly all the principal nations, except Germany, were exhibited either by actual products or by facsimiles.

We have not to concern ourselves here with the question of the culture of foods, for the agriculture is fully discussed under the eighth group, nor is it necessary to enter into an elaborate discussion of the chemical composition of foods and the relative importance of the various elements or compounds in the sustentation of the human body. The special topic is that of the methods of preparation and of preservation of food, and of their commercial importance. The subject will be treated in a general manner, and for further details the reader must be referred to the numerous exhaustive treatises on each class of foods considered.

A word, however, on the general composition and classification of foods may not be out of place. Animal foods, properly speaking, are meats, fowl, fish, mollusks and crustaceans, eggs, milk, etc. The vegetable foods are cereals, vegetables, fruits. The chemical elements entering into the composition of these foods are carbon, hydrogen, oxygen, phosphorus, sulphur, chlorine, calcium, sodium, etc. According to their composition, foods are divided into two principal classes:

(1) Nitrogenous foods, either of animal origin as meats, fish, eggs, and cheese, or of vegetable origin as the cereals, vegetables, and fruit.

(2) Nonnitrogenous foods, either of animal origin, as butter and lard, or of vegetable origin, as starch, tapioca, sugar, and honey.

The nitrogenous foods are also called albumenoids, and contain the four elements, nitrogen, carbon, hydrogen, and oxygen. The nonnitrogenous foods contain either the three elements, carbon, oxygen, and hydrogen, as starch and sugar, or, as in the case of butter, they contain chiefly carbon and hydrogen, with very little oxygen.

Foods are further subdivided into (1) fibrous, gelatinous, albuminous, oleaginous, etc.; (2) solid and liquid; (3) complete foods, as eggs and milk containing all the elements necessary to nutrition; and (4) incomplete foods, containing only a portion of the nutrient elements.

Animal food, meat, is of very great importance to man. In all climates, among both civilized and savage people, it has always been considered a necessity. There is often more essential food in a small piece of meat than in a mass of vegetables. Unfortunately, however, meat contains elements which quickly decompose its substance and render it unfit for use. To preserve meat so that it may lose as little as possible of its nutritive properties is a problem which has engaged the earnest attention of eminent scientists. The various processes of preservation are discussed under class 70, "preserved meats and fish."

COMMERCIAL STATISTICS.

The commercial importance of the food industries of the world is much greater than one would at first suppose. In our own country the food annually consumed is valued at upwards of $3,000,000,000 as the first cost, or probably more than $6,000,000,000 as the final cost to the consumer. The United States exports food products valued at about $250,000,000, and imports more than a like amount. The details of articles of import and export will be found in the discussion of the several foods, and further details may readily be referred to in the excellent reports of the Bureau of Statistics of the Treasury Department.

The total yield of cereals in the world, exclusive of rice, is 8,500,000,000 bushels, of which the United States produces 30 per cent, and Russia about 18 per cent. Of rice, the total yield is estimated at 206,250,000,000 pounds, grown chiefly in Asia. The United States grows 22 per cent of the 2,050,000,000 bushels of wheat annually produced. The total yield of rye is 1,375,000,000 bushels, of which Europe raises 98 per cent. Of barley, 865,777,000 bushels are grown, three-fourths of it in Europe. The crop of oats is 2,300,000,000 bushels,

more than one-fourth of which is grown in the United States, and another fourth in Russia. The United States produces 1,650,000,000 bushels of corn, or three-fourths of the entire crop of the world.

The flour-milling industry in the United States and France is of about equal importance, each country producing about 75,000,000 barrels per year.

The total consumption of bread in France is 8,045,000,000 kilograms, a general average of 580 grams for each inhabitant representing 450 grams of flour.

Of dairy products I have no general statistics for the whole world. In the United Kingdom the annual product of butter is one and one-half to two million hundredweight, and the imports are 300,000,000 pounds. The importation of cheese into the United Kingdom in 1888 was 215,000,000 pounds. In the United States there is made about 1,000,000,000 pounds of butter, and 250,000,000 pounds of cheese each year. France makes 225,000,000 pounds of cheese, and 150,000,000 pounds of butter. Switzerland exports about 440,000,000 pounds of cheese.

The sugar production of the commercial world is 5,200,000 tons per year, about one half of which is beet sugar and the other half cane sugar. There is also about 2,000,000 tons of cane and palm sugar made, and mostly consumed, in India.

The coffee crop of the world is 1,430,000,000 pounds, more than half of which is grown in Brazil. The United States consumes one-third of the total yield, or more than the combined consumption of Germany, the United Kingdom, Austria-Hungary, and France.

The tea crop of the world, not including the great local consumption in China, is 500,000,000 pounds. England and her colonies consume one half the entire crop. The Russians are also great tea drinkers. The United States uses each year between 80,000,000 and 90,000,000 pounds of tea.

The wine production of the world is about 3,000,000,000 gallons a year, of which Italy, France and Spain contribute about 2,000,000,000 gallons; Austria-Hungary, Germany and Portugal about 350,000,000 gallons, and Russia and Algiers about 175,000,000 gallons. The production in the United States is about 30,000,000 gallons, of which California contributes 16,000,000 gallons; Ohio, 3,000,000; New York, 3,000,000; Wisconsin, 2,000,000; Virginia, New Jersey, and North Carolina, 1,000,000 each, the remaining 3,000,000 being divided between Pennsylvania, Kentucky, Texas, Florida, Alabama, Georgia, etc.

Of spirits, France in 1888 made 2,069,419 hectoliters, and the consumption was 1,468,443 hectoliters, or 3.80 liters per capita.

In the United States the quantity of spirits distilled from apples, peaches, and grapes was 1,294,858 gallons in 1889, and from grain and molasses in the same year it was 75,868,671 gallons.

The largest beer brewery in the world is the establishment of Anheuser-Busch, at St. Louis, where 510,313 barrels of beer were made in 1888. The next largest single brewery is at Munich, 413,850 barrels in 1887. The Empire and Schlitz breweries at Milwaukee made 667,249 barrels of beer in 1887.

The total consumption of alcoholic beverages in the United States in 1889 was 894,655,061 gallons, made up as follows:

	Gallons.
Distilled spirits consumed:	
Spirits of domestic product:	
From fruit	1,294,858
All other	77,802,483
Imported	1,515,817
	80,613,158
Wines:	
Wines of domestic product	29,610,104
Imported wines	4,534,373
	34,144,477
Malt liquors:	
Malt liquors of domestic product	777,420,207
Imported products	2,477,219
	779,897,426
Total of all kinds	894,655,061

The consumption per capita of all wines and liquors was 6.43 gallons in 1860; 7.69 in 1870; 10.09 in 1880, and 13.86 in 1889. The consumption of distilled liquors per capita has gradually declined from 2.86 gallons in 1860 to 1.25 in 1889; that of wines has gradually increased from 0.35 gallons in 1860 to 0.53 in 1889, and that of malt liquors has increased from 6.43 gallons in 1860 to 12.68 in 1889.

The value of food products imported into the United Kingdom in 1887 was $128,290,000, and in 1888 it was $124,290,000. The exports of foods of domestic production in 1887 was valued at $46,945,000, and in 1888 at $51,000,000.

Spanish America, including South and Central America, with a total population of about 50,000,000 people, exports annually sugar, coffee, cocoa and fruits valued at $125,000,000, besides considerable quantities of other foods, and imports foods to the value of $175,000,000.

I give below some statistical tables that may be useful for reference. The farm value of the agricultural food products of the United States during the year ended June 30, 1887, and the percentage of such products exported were as follows:

Farm value of products in United States in 1887.

Food products.	Production.	Per cent exported.	Food products.	Production.	Per cent exported.
Corn	$610,311,000	1.9	Potatoes	$77,441,940	0.3
Wheat	314,226,020	27.9	Sweet potatoes	20,000,000	....
Oats	186,137,930	0.2	Peas and beans	13,800,000	3.3
Barley	31,840,510	2.2	Onions and other products of market gardens	68,000,000	0.4
Rye	13,181,330	1.5	Fruits	175,000,000	0.9
Buckwheat	6,465,120	....	Sugar, molasses, and honey	33,500,000	....
Rice	5,000,000	0.5	Wines	10,000,000	1.3
Meats	748,000,000	8.4		2,879,903,850	
Poultry and eggs	186,000,000	0.04			
Butter	192,000,000	0.8			
Cheese	32,000,000	20.2			
Milk	156,000,000	0.1			

Value of food products imported for consumption in United States.

Year.	Imports.	Exports.	Year.	Imports.	Exports.
1882	$322,445,000	$169,608,000	1886	$297,355,000	$141,122,000
1883	316,173,000	163,934,000	1887	274,639,000	135,679,000
1884	277,611,000	151,196,000	1888	297,700,000	140,000,000
1885	280,873,000	144,711,000	1889	281,400,000	163,000,000

In 1887 France imported for home consumption articles of food and drink to the value of $274,639,000, more than one-third of the total import into the country. The exports of alimentary substances of home production in the same year were valued at $135,679,000. Among the principal items imported were:

Butter and cheese	$7,874,000	Rice	$3,686,000
Cocoa	4,381,000	Sugar	9,554,000
Coffee	19,918,000	Vegetables (dried and flour of)	3,513,000
Fish (salt water)	10,847,000	Wheat and other cereals	50,644,000
Fruits for table use	24,704,000	Wines	109,254,000
Meat (fresh, salted, etc.)	7,508,000		

Among the exports were:

Brandy and spirits	$14,359,000	Meats, fresh and preserved	$2,335,000
Butter and cheese	17,158,000	Sugar	10,345,000
Eggs	5,172,000	Wheat and other cereals	5,771,000
Fish	6,272,000	Wines	50,103,000
Fruits	8,299,000		

The following tables give the details of imports and exports of food products for the United Kingdom during the years 1887 and 1888:

Imports into United Kingdom of Great Britain and Ireland for the years ending December 31, 1887 *and* 1888.

a. FREE OF DUTY.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Animals, living (for food).				
Oxen and bulls:				
Denmark	25,079	27,385	£295,295	£334,451
Germany	7,873	10,304	123,672	176,347
Spain	6,653	11,484	108,428	188,614
Canada	62,537	58,761	1,089,352	1,036,269
United States	94,642	142,865	1,849,307	2,840,911
Other countries	22,438	36,467	336,601	554,245
	219,222	287,266	3,802,655	5,130,837
Cows	38,766	49,724	489,063	634,982
Calves	37,973	40,098	147,087	146,155
Sheep and lambs	971,403	956,210	1,645,837	1,740,549
Swine	21,965	24,509	64,424	74,784
	....	....	6,149,066	7,727,307
Articles of food and drink.				
Wheat:				
Russia ....cwt.	5,522,773	21,368,793	1,990,689	8,097,723
Germany ....do.	1,551,738	3,264,815	599,292	1,298,675
France ....do.	70,980	20,235	26,626	7,209
Turkey ....do.	1,989	182,441	677	65,892
Roumania ....do.	585,353	1,419,079	195,715	550,119
Egypt ....do.	197,787	729,781	67,266	234,349
United States—				
On Atlantic ....do.	20,537,419	6,224,040	7,971,450	2,405,560
On Pacific ....do.	9,967,107	8,423,155	4,014,768	3,278,482
Chile ....do.	2,206,272	1,485,710	836,529	570,566
British East Indies ....do.	8,509,095	8,188,698	3,102,159	3,066,803
Australasia ....do.	1,347,151	2,315,700	531,203	1,013,186
British North America ....do.	3,964,784	1,089,080	1,510,305	434,385
Other countries ....do.	1,322,237	2,513,407	489,223	948,882
	55,784,685	57,224,934	21,335,902	21,971,831
Wheat meal and flour ....cwt.	18,056,545	16,912,723	10,020,433	9,530,803
Barley ....do.	14,277,180	21,277,477	3,769,272	6,069,190
Oats ....do.	14,468,733	18,737,436	3,489,818	4,588,712
Pease ....do.	2,990,296	2,420,847	875,016	705,747
Beans ....do.	2,477,293	3,010,144	787,976	920,088
Indian corn or maize ....do.	31,123,401	25,338,551	7,535,946	6,881,307
Indian corn meal ....do.	5,522	14,846	4,934	8,046
Total cereals ....do.	....	....	47,819,297	50,675,224
Bacon:				
From Germany ....cwt.	359,172	253,016	1,028,795	666,599
From United States ....do.	2,203,103	1,865,130	4,228,559	3,852,961
From other countries ....do.	438,536	736,390	1,072,536	1,873,399
	3,000,811	2,854,536	6,329,890	6,392,959

Imports into United Kingdom of Great Britain and Ireland, etc.—Continued.

a. FREE OF DUTY—Continued.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Beef, salted:				
From United States................cwt...	203,112	213,376	£309,576	£325,134
From other countries ....do....	15,325	13,160	24,474	24,125
	218,437	226,536	334,050	349,259
Beef, fresh:				
From United States.. ....cwt...	644,700	785,214	1,456,446	1,814,923
From other countries ... .do....	12,874	52,230	24,737	105,924
	657,574	837,444	1,481,183	1,920,847
Hams:				
From United States... ....cwt..	814,304	646,672	2,097,394	1,696,871
From other countries........ ......do....	106,313	81,633	292,657	227,065
	920,617	728,305	2,390,051	1,923,936
Meat, unenumerated, salted or fresh:				
From United States.... ....cwt...	5,828	3,254	2,630	6,269
From other countries ....do....	41,207	53,527	103,020	114,282
	47,035	56,781	115,650	120,551
Meat, preserved otherwise than by salting:				
From Belgium .. ..cwt...	11,754	15,561	176,204	194,201
From Australasia ....do....	167,177	128,291	386,920	267,076
From United States ....do....	227,435	263,458	530,966	630,071
From other countries ....do....	112,814	135,289	255,895	285,675
	519,180	542,599	1,349,985	1,377,023
Mutton, fresh:				
From Holland......................cwt...	62,887	87,779	151,826	190,227
From Australasia ....do....	441,289	543,117	929,833	1,104,173
From Argentine Republic..........do....	251,273	346,806	442,597	627,888
From other countries ....do....	29,392	11,383	57,345	18,691
	784,841	989,085	1,581,601	1,940,979
Pork (salted, not hams):				
From United States.................cwt..	191,512	149,525	274,550	237,633
From other countries...............do....	82,320	95,366	118,671	122,288
	273,832	244,891	393,221	359,621
Pork, fresh:				
From Holland.......................cwt..	117,924	191,218	293,051	433,056
From Belgium............ ....do....	29,773	34,939	71,248	82,131
From United States ....do....	152	8	310	18
From other countries...............do....	5,886	16,613	14,994	41,749
	153,735	242,778	379,603	556,954
Rabbits	117,058	100,872	311,866	276,562
Total of dead meat	....	....	14,662,100	15,218,991
Butter ....cwt..	1,514,905	1,669,314	8,016,769	8,902,193
Margarine (butterine)..................do...	1,273,095	1,138,174	3,869,948	3,263,826
Cheese ....do...	1,834,467	1,917,541	4,508,937	24,542,278
Eggs	9,069,837	9,320,617	3,080,561	3,077,109
Fish, cured or salted	684,324	823,103	1,272,973	1,553,778
Fruit, apples, raw .... bush..	1,948,843	3,821,946	565,392	1,037,084

Imports into United Kingdom of Great Britain and Ireland, etc.—Continued.

a. FREE OF DUTY—Continued.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Oranges and lemons	4,857,414	4,879,995	£1,560,116	£1,464,640
Unenumerated, raw	2,479,004	3,039,100	1,167,095	1,387,271
Hogs ....cwt..	145,298	215,927	428,250	796,404
Lard	906,190	883,469	1,601,635	1,815,420
Onions ....bush..	3,649,471	3,479,418	617,710	641,256
Potatoes ....cwt..	2,762,958	2,384,144	974,133	802,110
Poultry and game, alive and dead	....	....	409,183	403,197
Rice:				
British East Indies ....cwt..	4,322,449	3,935,577	1,1510,564	1,419,832
Other countries ....do...	711,384	2,268,250	367,405	894,223
Total	5,033,833	6,203,827	1,877,969	2,314,055
Spices:				
Cinnamon ....lbs..	1,109,978	1,351,990	44,436	42,845
Ginger ....cwt..	75,157	69,229	141,859	130,207
Pepper ....lbs..	29,811,852	28,704,898	1,021,991	918,693
Total	....	....	1,208,286	1,091,745
Sugar, refined, and candy:				
Germany ....cwt..	2,834,924	3,177,340	2,204,566	2,768,246
Holland ....do...	1,503,522	1,426,276	1,186,828	1,290,654
Belgium ....do...	216,717	203,888	181,184	193,316
France ....do...	1,551,435	1,570,237	1,189,280	1,876,741
United States ....do...	782,552	41,628	627,798	38,960
Other countries* ....do...	121,612	470,479	88,801	375,559
Total	7,010,762	6,889,848	5,478,457	6,043,476
Sugar, unrefined:				
Germany ....cwt..	7,573,636	5,320,106	4,488,678	3,495,698
Holland ....do...	408,404	283,549	231,020	182,577
Belgium ....do...	1,06 ,683	694,302	640,351	437,831
France ....do...	68,186	37,367	41,426	27,398
British West Indies and Guiana ....do...	2,148,245	2,140,438	1,557,883	1,725,522
British East Indies ....do...	853,663	1,006,913	410,072	483,865
China and Hongkong ....do...	16,312	10,733	12,201	6,420
Mauritius ....do...	104,986	256,463	57,498	173,872
Spanish West India Islands ....do...	176,358	304,496	109,330	223,544
Brazil ....do...	865,285	2,267,225	476,603	1,425,784
Java ....do...	3,200,343	3,612,487	2,085,627	2,704,310
Philippine Islands ....do...	460,386	722,425	210,438	345,317
Peru ....do...	436,634	497,142	277,307	369,075
Other countries ....do...	574,108	696,725	335,843	507,154
Total	17,955,229	17,850,371	10,934,277	12,107,367
Molasses	305,528	346,025	101,822	109,485
Vegetables, raw, unenumerated	....	....	600,882	621 771
Yeast ....cwt..	284,883	268,498	773,869	733,032
Total value of articles of food and drink	....	....	116,930,359	124,281,097

*Mostly from Russia.

Imports into United Kingdom of Great Britain and Ireland, etc.—Continued.

b. DUTIABLE.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Chicory:				
Imports ....cwt..	138,090	116,059	£80,435	£74,084
Home consumption....... ... .do...	106,127	100,413		
Cocoa:				
Imports ....lbs..	27,459,500	29,566,547	910,241	933,365
Home consumption.... ....do...	15,873,698	18,227,017	....	....
Coffee:				
Ceylon ....cwt..	133,996	107,055	578,731	437,702
Other British Possessions .... do...	185,236	276,610	794,155	1,109,233
Brazil ....do..	300,495	160,258	1,095,443	497,418
Central America ....do...	245,344	229,543	1,064,284	890,802
Other countries ....do...	181,141	181,808	720,618	650,058
Total:				
Imports.................	1,046,212	955,274	4,253,231	3,585,213
Home consumption....	268,322	277,994		
Currants:				
Imports ....cwt.	1,097,001	1,029,380	1,444,975	1,350,193
Home consumption ....do ...	921,238	1,016,939		
Raisins:				
Imports ....cwt..	654,357	590,000	1,033,406	907,255
Home consumption ....do...	513,577	489,603		
Tea:				
From British East Indies ....lbs..	97,830,117	113,004,692	5,011,090	5,679,507
China (including Hongkong and Macao) ....do...	119,739,116	105,424,271	4,670,724	4,336,290
Other countries ....do...	5,194,054	5,189,515	177,269	200,304
Total:				
Imports...........................	222,763,287	223,618,478	9,859,083	10,216,101
Home consumption...........	183,635,885	185,556,214		
Spirits (not sweetened or mixed):				
Brandy:				
Imports ....proof gall..	2,830,916	2,647,065	1,317,976	1,219,155
Home consumption ....do...	2,543,949	2,444,571		
Rum:				
Imports ....do...	6,378,377	4,147,656	507,849	336,356
Home consumption ....do...	3,902,325	3,856,365		
Other sorts:				
Imports ....do...	2,618,097	3,214,784	185,800	203,032
Home consumption ....do...	2,135,693	2,725,314		
Total:				
Imports . ...do...	11,827,390	10,009,505	2,011,625	1,758,543
Home consumption ....do...	8,581,967	9,026,250		
Wine imports:				
British Possessions in South Africa.galls..	48,445	37,927	17,699	13,365
Other British Possessions ....do...	168,189	232,939	36,666	46,184
Germany ... . do...	402,188	416,375	59,820	77,140
Holland ....do...	418,864	398,770	290,836	236,635
France:				
Red ....do...	3,895,281	3,764,445	1,052,678	983,715
White ....do...	1,774,593	1,870,125	1,732,018	1,982,344

Imports into United Kingdom of Great Britain and Ireland, etc.—Continued.

b. DUTIABLE—Continued.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Wine imports—Continued.				
Portugal... ... .do...	3,451,156	3,160,360	£1,063,203	£940,115
Madeira .. .. do ..	94,054	169,468	36,106	54,417
Spain:				
Red ....do...	1,486,859	1,394,782	198,788	175,649
White ....do...	2,943,761	2,518,593	813,233	712,739
Italy....... ....do...	530,789	553,538	110,821	102,475
Other countries ....do...	164,948	217,705	56,069	61,589
Total:				
Of wine ... .do...	15,379,126	14,735,027	5,467,377	5,386,367
Red ....do...	9,477,560	9,210,332	2,444,321	2,267,086
White ....do...	5,901,566	5,524,694	3,023,556	3,119,281
Wine entered for home consumption:				
France:				
Red....................................	3,838,114	3,741,511	....	....
White	1,538,399	1,569,495	....	....
Portugal..............	2,981,049	2,978,006	....	....
Spain:				
Red...	1,183,462	1,159,075	....	....
White	2,549,637	2,374,171	....	....
Other countries	1,603,815	1,677,851	....	....
Total:				
Of Wine.........	13,694,476	13,500,109	....	....
Red..............................	8,588,015	8,620,474	....	....
White	5,106,451	4,879,635	....	....
Total value of articles of food and drink.....	....	....	25,780,979	24,958,798
Total value of all imports......................	....	....	361,935,006	386,582,026

Exports of food products from the United Kingdom during the years ending December 31, 1887 *and* 1888.

DOMESTIC PRODUCTS AND MANUFACTURES.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Beer and ale:				
Egypt..............................bbls..	13,075	7,986	£44,133	£26,191
United States.......................do...	42,591	45,494	180,035	202,608
British Possessions in South Africa..do...	25,351	22,338	95,356	83,830
British East Indies. ....do...	60,518	73,676	210,616	238,308
Australasia ....do...	138,346	138,211	574,477	588,684
British West India Isles and Guiana. do...	23,141	20,037	99,479	84,707
Other countries.....................do...	137,845	140,174	474,264	481,841
Total	440,867	447,916	1,678,360	1,706,169
Butter............................ ..cwt..	27,794	25,618	56,774	145,730
Cheese................. ....do...	14,321	12,799	6,753	50,743
Fish, herrings.........................bbls..	1,014,742	971,891	1,0 6,402	1,106,780
Other kinds...............	....	....	4 7,332	462,790

Exports of food products from the United Kingdom, etc.—Continued.

DOMESTIC PRODUCTS AND MANUFACTURES—Continued.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Hops ....cwt..	12,515	8,282	£ 49,994	£48,357
Pickles, vinegar, sauces, condiments, and confectionery	....	....	1,193,727	1,367,544
Provisions (including margarine, meat)........	....	....	996,963	1,056,582
Salt, rock and white........tons..	818,713	899,270	524,860	486,651
Spirits, British and Irish:				
France ....gall..	25,158	27,812	8,234	9,514
West Coast of Africa ....do...	243,452	297,252	25,405	28,583
United States ....do...	149,518	153,993	46,030	47,965
British Possessions, South Africa....do...	127,987	139,884	60,788	67,400
British East Indies........do...	444,951	432,846	183,683	184,075
Australasia ....do...	1,589,160	1,736,588	524,564	593,055
British North America ....do...	181,085	172,966	57,417	58,252
Other countries........do...	344,968	382,499	135,108	148,136
	3,106,279	3,325,640	1,041,229	1,136,980
Sugar, refined, and candy:				
Sweden and Norway........	79,162	81,751	57,252	68,136
Denmark........	112,319	102,725	65,639	75,472
Holland	78,240	92,665	52,993	66,798
Belgium........	40,991	31,734	25,270	21,569
France	33,017	7,393	21,204	5,186
Portugal, Azores, and Madeira	83,513	77,196	50,684	56,603
Italy	99,458	93,061	65,444	68,860
Other countries	178,191	193,155	126,527	150,502
Total........	704,891	681,680	465,013	513,126
Other articles........	....	....	1,722,023	2,158,091
Total value of articles of food and drink........	....	....	9,389,430	10,242,543

FOREIGN AND COLONIAL PRODUCE.

Bacon ....cwts..	171,134	148,664	£298,769	£270,670
Butter	70,616	64,393	373,021	326,758
Margarine	22,180	20,457	53,482	50,614
Cheese	50,856	58,869	147,564	172,105
Chicory	18,304	14,209	16,102	13,816
Cocoa ....lbs..	8,088,783	7,932,127	276,615	255,627
Coffee ....cwt..	682,887	807,609	2,634,638	3,043,799
Corn wheat	619,548	391,925	238,703	156,070
Wheat meal and flour	171,267	190,584	93,761	106,151
Currants	71,134	80,415	79,523	88,829
Fish, cured and salted	308,258	319,986	516,787	492,262
Oranges and lemons ....bush..	482,122	598,731	149,333	167,679
Meats, preserved........cwt..	70,864	35,470	184,828	96,350
Raisins	79,743	100,740	109,993	136,466
Rice	2,472,156	2,916,773	1,080,788	1,264,021
Spices:				
Cinnamon ....lbs..	1,222,500	1,121,324	46,330	40,590
Pepper ....do...	20,615,400	18,211,082	662,921	591,968

Exports of food products from the United Kingdom, etc.—Continued.

FOREIGN AND COLONIAL PRODUCE—Continued.

	Quantity.		Value.	
	1887.	1888.	1887.	1888.
Spirits, unsweetened:				
Brandy .... proof gall..	127,867	96,678	69,660	57,867
Rum	1,534,789	1,297,990	245,949	202,670
Other sorts	308,550	202,367	33,047	21,800
Mixed in bond	380,646	401,434	45,114	46,073
Sugar:				
Refined and candy .... cwt..	291,782	186,797	229,738	169,773
Unrefined .... do...	481,121	1,130,964	337,117	827,170
Molasses	55,830	134,177	21,069	52,981
Tea .... lbs..	34,741,393	37,956,842	1,666,115	1,780,627
Wine:				
Red .... gall..	566,958	590,964	207,522	205,023
White .... do...	635,202	672,930	335,500	380,137
Mixed in bond	14,135	11,208	2,866	2,252

Exports of food products from British India during the year ended March 31, 1889.

Coffee (of which 176,810 cwt. went to the United Kingdom and 121,144 cwt. to France) cwt..	365,299
Rice:	
In husk .... do...	376,412
Not in husk (of which 6,327,791 went to Egypt, 4,260,371 cwt. to the United Kingdom, and 3,331,373 cwt. to China) .... cwt..	22,768,229
Wheat (of which 9,037,830 cwt. went to the United Kingdom, 3,131,551 cwt. to France, and 2,477,730 cwt. to Belgium) .... cwt..	17,610,081
Oats .... do...	256,181
Pulse (of which 427,633 cwt. went to the United Kingdom) .... do..	618,489
Jowari .... do...	611,960
Barley .... do...	25,053
Flour .... do...	36,290,371
Dried and preserved fruits and vegetables .... do...	141,264
Ghi .... do...	2,175,171
Lard .... do...	724,279
Salt fish .... do...	6,146,797
Spices:	
Betel nuts .... pounds..	328,056
Cardamoms .... do.....	377,241
Cassia .... do.....	112
Cinnamon .... do.....	12,530
Cloves .... do. ...	336
Ginger (of which 6,024,946 pounds went to the United Kingdom) .... do.....	10,212,971
Nutmegs .... do.....	190
Pepper (of which 4,692,830 pounds went to France) .... do.....	7,666,007
Sugar:	
Refined .... cwt..	34,523
Unrefined (of which 822,685 cwt. went to the United Kingdom) .... do...	978,955
Tea (of which 93,222,078 pounds went to the United Kingdom) .... pounds..	97,011,112

CLASS 67.---CEREALS AND FARINACEOUS PRODUCTS.

CLASS 67.—CEREALS AND FARINACEOUS PRODUCTS AND THEIR DERIVATIVES.

I.—AWARDS: GENERAL STATISTICS OF CEREAL PRODUCTION.

The exhibits in this class of food products included all varieties of cereals in the grain, and preparations made from them, and flour, meal, pearl barley, semolinas, macaroni, and other alimentary pastes; also tapioca, sago, and starches made from wheat, corn, rice, potatoes, and from other sources, glucose, etc. The number of exhibitors in this class were eight hundred and forty, which, however, included several collective exhibits representing many individuals. The countries exhibiting and the awards granted were as follows:

Awards in Class 67.—Cereals, etc.

Country.	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
France	3	47	25	7	4	88
Algeria	1	13	14	23	34	82
Argentine Republic	1	7	15	23	10	56
Mexico	....	2	8	22	7	39
Brazil	....	5	7	15	6	33
Uruguay	....	5	6	7	9	27
Japan	1	3	4	10	7	25
Spain	....	4	10	6	5	25
Chile	....	4	5	6	8	23
Russia	1	12	5	4	1	23
Guatemala	....	....	3	9	11	23
Salvador	....	....	3	6	13	22
Victoria, Australia	1	10	2	9	....	22
Roumania	....	3	5	7	8	23
New Caledonia	....	1	7	7	3	18
Servia	....	4	3	6	4	17
Greece	....	1	6	4	2	13
Netherlands	....	4	5	1	2	12
Belgium	1	3	5	1	1	11
Austria-Hungary	1	2	....	6	....	9
United States	1	5	2	1	1	10
Réunion	....	....	2	6	1	9
Great Britain	....	4	2	2	....	8
Senegal	....	5	2	....	....	7
New Zealand	....	3	3	....	....	6
Ecuador	....	....	1	3	2	6
Italy	....	....	1	3	1	5
Cochin China	....	5	....	....	....	5

Awards in Class 67.—Cereals, etc.—Continued.

Country.	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
Dominican Republic			3	1		4
Tunis			3	1		4
Portugal		1	1	2		4
South Africa Republic		1	1	1	1	4
Switzerland		1	2	1		4
Finland		1	1	2		4
Guadeloupe			4			4
Nicaragua			1	2		3
Venezuela		2		1		3
Spanish Colonies		3				3
French East Indies			1		1	2
Martinique			1		1	2
Puerto Rico			2			2
Philippine Islands	1		1			2
Paraguay			1	1		2
Bolivia		1	1			2
Persia			1			1
Siam		1				1
San Marino			1			1
Norway				1		1
Hawaiian Islands		1				1
Tahiti			1			1
Total	12	164	175	206	143	700

As stated on a previous page the annual harvest of cereals, exclusive of rice, in the world is about 8,500,000,000 bushels, more than 30 per cent of which is grown in the United States, and about 18 per cent in Russia.

I give below the cereal crop of most of the principal countries for various years, it being impossible to ascertain the exact statistics of all countries for any one recent year:

Country.	Year.	Bushels.	Country.	Year.	Bushels.
Canada	1885	97,900,000	Hungary	1886	325,015,422
United States*		2,703,036,457	Portugal	1877	34,214,576
Mexico			Spain	1884	226,173,145
Central America		162,000,000	Italy	1886	235,004,210
South America			Greece	1877	10,525,854
United Kingdom†		318,038,278	Switzerland		17,473,296
Norway	1875	16,915,643	Servia		14,308,520
Sweden	1887	106,524,779	Roumania	1881	102,850,000
Denmark	1885	87,834,424	Russia‡		1,581,984,411
Netherlands	1885	37,772,800	Turkey	1885	110,341,440
Belgium	1884	71,966,027	Egypt	1885	61,875,000
France	1886	741,187,972	Algeria	1885	147,675,000
Germany	1886	801,841,939	India	1885	765,000,000
Austria	1883	313,227,568	Australia	1885	35,750,000

*Average, 1880 to 1888. †Average. ‡Average, 1883 to 1888.

The production of rice in the world, as shown on a subsequent page, is estimated at 100,000,000 tons, or 206,250,000,000 pounds. It is chiefly grown and consumed in Asia.

II.—COUNTRIES EXHIBITING CEREALS.

(1) AMERICA.

There were no exhibits at the Paris Exposition from Canada, or other parts of British America. The cereal industry has been very greatly developed in Canada during the last 10 years, the crop in 1885 aggregating nearly 100,000,000 bushels.

UNITED STATES.

The exhibits from the United States, of which a list is given below, included samples of all the commercial grades of grain, flour, and the numerous preparations of farinaceous food peculiar to our country.

Board of Trade, Chicago, Illinois. Grain in sacks and in cases, representing the various grades officially established by the State inspection of Illinois, together with a chart illustrating the extent of the grain business of Chicago.

Board of Trade, Minneapolis, Minnesota. Grain, showing the different grades of quality established officially by the State.

A. D. Butler, commissioner of agriculture for South Carolina. Rice, the raw finished product, including sixteen specimens representing the various processes of the milling.

Collective exhibit of cereals prepared under the direction of the Secretary of Agriculture, Washington, District of Columbia.—Contributors: G. E. Morrow, professor of agriculture, Illinois University, Champaign, Illinois. Charles E. Thorne, director agricultural experiment station, Columbus, Ohio. C. L. Ingersoll, president State Agricultural College, Fort Collins, Colorado. Luther Foster, professor of agriculture, Brookings, Dakota. R. W. Furnas, ex-governor, Lincoln, Nebraska. C. C. Whitney, Marshall, Minnesota. F. L. Whitney, general passenger agent, St. Paul, Minneapolis and Manitoba Railroad, St. Paul, Minnesota. Gen. J. C. Black, Washington, District of Columbia. J. P. Silver, Glenville, Maryland. The A. B. Cleveland Company, New York. J. H. Bretz, Oakdale, Nebraska. J. R. Gwynn, Clinton, Missouri. Professor Henry, director agricultural experiment station, Madison, Wisconsin. R. H. Vanderhoof, Newton, Illinois. A. F. Haase, Dakota City, Nebraska. Prof. C. E. Bessey, Lincoln, Nebraska. J. F. Nelson, Olney, Illinois. J. P. Higgins, Calhoun, Illinois. M. Fairchilds Dowd, Kansas City. C. L. Gabilson, New Hampton, Iowa. Nimo Brothers, Emerson, Iowa. E. M. Upson, Cummings, Dakota.

Glen Cove Manufacturing Company, New York, New York. Samples of "maizena," grape sugar, and glucose.

Prof. C. L. Ingersoll, president agricultural college, Fort Collins, Colorado. Eight large plaques with designs formed of the various grains and grasses grown in Colorado.

C. A. Pillsbury & Co., Minneapolis, Minnesota. Wheat in sacks representing the grades officially established; flour in its various stages of manufacture.

T. Schumacher & Co., Akron, Ohio. Various finished cereal products.

Charles Hervey Townshend, New Haven, Connecticut. "Wheatine," "wheatiaba," "johnny cake," and other derivations of wheat, corn, and buckwheat.

August Vogt, Wills Point, Texas. One bushel of white corn.

The average annual value of cereals grown in the United States from 1880 to 1888 was $1,284,477,973, and the annual harvest was 2,703,036,457 bushels.

The commercial importance of wheat, rye, and other cereals is discussed in the paragraphs devoted to those products.

Production of cereals in the United States, 1849, 1859,1869, 1879, 1888.

	1849.	1859.	1869.	1879.	1888.
Corn	592,071,104	838,792,742	760,944,549	1,754,591,676	1,988,000,000
Wheat	100,485,944	173,104,924	287,745,626	459,483,137	416,000,000
Oats	146,584,179	172,643,185	282,107,157	407,858,999	702,000,000
Rye	14,188,813	21,101,380	16,918,795	19,831,595	25,000,000
Barley	5,167,015	15,825,898	29,761,305	43,997,495	58,000,000
Buckwheat	8,956,912	17,571,818	9,821,721	11,817,327	11,000,000

Farm value of cereal production and of exports during the fiscal year 1886–'87.

	Production.	Exports.
Corn	$610,311,000	$11,790,046
Wheat	314,226,020	87,668,833
Oats	186,137,930	343,659
Barley	31,840,510	691,809
Rye	13,181,330	197,687
Buckwheat	6,465,120	....
Rice	5,000,000	26,284
Total	1,167,161,910	100,718,318

WEST INDIES.

Martinique showed several kinds of starch. The exhibits of cereals from Guadeloupe consisted of rice, arrowroot, corn, manioc, flour, and cashew nuts.

The Dominican Republic had six exhibits of rice, arrowroot, and alimentary pastes, and a variety of starches.

MEXICO.

Mexico had an interesting exhibit of corn, barley, wheat, rye, rice, wheat and corn flour, starches, and other cereal productions of that country. The Mexicans make a flour from black beans, with which they prepare a dish much esteemed by them.

CENTRAL AMERICA.

Salvador exhibited a great variety of cereals of fine quality, especially corn, rice, wheat, and barley, and various farinaceous preparations including macaroni, vermicelli, yuca starch, etc. The corn shown in white, red, and black varieties, with large and small grains, was especially interesting.

Guatemala exhibited some rice, black maize, white maize, wheat, starch of yuca, flour, etc.

Nicaragua showed a few samples of rice, manioc starch, and three varieties of corn.

SOUTH AMERICA.

Venezuela exhibited in Class 67 corn, starches, and a variety of farinaceous products.

Bolivia had a few samples of cereal products.

Brazil had seventeen exhibits of cereal products, including wheat and corn flour, tapioca, arrowroot, some excellent samples of starches, and a variety of preparations of manioc.

Chile made a very complete exhibit of cereal products, including corn, wheat, oats, and other grains in great variety, and some samples of flour and vermicelli made in that country.

From Ecuador there was shown some corn, wheat, barley, millet, flour of corn and of wheat, yuca starch, and potato starch.

Paraguay showed some flour, vermicelli, and manioc starch.

Uruguay exhibited some tender and hard wheat, some barley, corn, rice, flours of wheat and corn, and some alimentary pastes.

The Argentine Republic made a very comprehensive display of cereals and their derivatives, including two hundred and fourteen exhibits of all varieties of grain, flour, alimentary pastes, and starches. Very great progress has been made in the agricultural industries during the last ten years, and especially since the tide of European emigration began toward this enterprising country. The people are still largely dependent on importations of foods to supply their needs, but the home products are fast replacing purchases from foreigners. In 1887 the Argentine Republic imported 5,401,096 kilograms of flour valued at $378,076. The exports of cereal production in the same year were 361,844,305 kilograms of corn valued at $7,236,886, and 237,865,925 kilograms of wheat at $9,514,635.

(2.) Europe.

THE UNITED KINGDOM.

Great Britain did not make an exhibit of cereals commensurate with the importance of her share in the production of this food staple. The collection included white and red wheat, white oats, rice and its products in all its forms, extract of malt, granulated preparations, and some arrowroot.

The climate of England is mild and damp. Frequent fogs and haze temper the winter's cold and the summer's heat. It is the hazy sky that gives England and Scotland their perpetual verdure. In England and Scotland there are 18,531,500 acres of cultivated lands. In England wheat covers 3,320,000 acres, barley 2,650,000 acres, and oats 2,737,500 acres. The climate is not suitable for corn. In Scotland oats occupy 1,032,500 acres, barley 268,500 acres, and wheat 81,250 acres. The western portion of the country, because of its damp atmosphere, is least suitable for cereal culture. The eastern region is the land of wheat and barley.

Many varieties of wheat are grown in England and Scotland, nearly all of them with handsome, tender grains. Oats are grown chiefly in the northern districts. Ireland possesses 5,270,000 acres of arable land. Wheat is cultivated only on 120,000 acres, and potatoes on 880,500 acres.

To resume: England, Ireland, and Scotland cultivate annually 3,521,250 acres in wheat, 3,138,500 acres in barley, and 6,745,000 acres in oats, altogether a total of 13,404,750 acres, or one-sixth the total area of the country. The United Kingdom produces only about half the wheat needed for home consumption.

The production of cereals in 1888 was 71,939,100 bushels of wheat, 68,482,089 bushels of barley, 107,283,392 bushels of oats.

The immense interests of England as a purchaser of grain are shown by the general statistics of importation given on a previous page, from which it appears that the aggregate imports in 1888 were valued at $253,375,000.

FRANCE.

The exhibit of cereals and their derivatives by France was very comprehensive and was admired by everyone.

France may be divided into nine agricultural regions or districts:

(1) The northwest region includes Normandie, Picardie, Artois, and Flandre. The cereals are here productive, as also is the sugar beet.

(2) The region of the Northern Plains includes Beance, Brie, Ile-de-France, and Champagne. Wheat, rye, barley, and oats are extensively grown here.

(3) The western region, or buckwheat region, includes Brittany, Maine, and Anjou.

(4) The region of the Central Plains includes Berry, Bologne, Touraine, Nivernais, and Bourbonnais.

(5) The northeast region, or hop district, includes the Ardennes, Lorraine, and the Vosges.

(6) The eastern region includes Franche-Comte, Bourgogne, Savoie, Lyonnais, and Dauphine. Here they make wine of fine quality. Wheat is extensively cultivated, and corn grows well.

(7) The region of Central Mountains includes Auvergne, Forez, Limousin, and the Marches. It is very mountainous and has fine pasturage for goats and cattle. Rye is here widely grown.

(8) The southwest region, or corn district, abounds in wide plains and beautiful valleys. It includes Bordelais, Perigord, Agenais, Bearne, Armagnac, and higher Languedoc. Here corn is chiefly grown.

(9) The southern region, or olive district, includes lower Languedoc, Provence, Comtat, and the county Nice and Corse. Besides being a region for olive, fig, and almond culture, it produces some good wheat with long grains.

The average area cultivated and the average annual yield of the principal cereals of France for the 10 years 1878 to 1887 were as follows:

Cereals.	Hectares (2½ acres.	Hectoliters (2¾ bushels.)
Wheat	6,926,799	104,065,145
Méteil (wheat and rye mixed)	377,416	5,717,262
Rye	1,744,850	24,307,662
Barley	1,006,860	18,983,047
Oats	3,580,932	83,866,365
Buckwheat	633,542	10,114,887
Corn	600,467	9,380,820

SWEDEN AND NORWAY.

There was no exhibit of cereals from Sweden, and only one from Norway. These two countries, politically united, are separated by a range of mountains. Sweden has only two seasons, summer, which is temperate, and winter which lasts five or six months. Its climate is moist, but vegetation is very active during the fine season. Rye is not cultivated above the Arctic circle, but barley is raised as far north as 69° north latitude.

Agriculture has made great progress in the fertile provinces of southern Sweden. The annual production of cereals is about as follows:

	Hectoliters.
Wheat	1,180,000
Rye	7,000,000
Barley	5,700,000
Oats	17,000,000
Wheat and rye mixed	1,800,000

The barley and oats are largely exported, but wheat and the other cereals are not sufficient for the home consumption which is augmented by imports from Russia, Denmark, and Germany. Barley and rye are the staple foods of the Scandinavians.

In Norway the winters are cold and long. The summers last about four months and are warm. Barley is the principal cereal cultivated. Wheat is planted at the end of August, and harvested at the end of September or beginning of October of the following year. It is raised as far north as 74° north latitude. In the mountainous regions of Scandinavia agriculture in general stops at an altitude of about 1,800 feet. Oats is the only cereal exported by Norway. Wheat, rye, barley, and flour are imported.

NETHERLANDS.

The Netherlands possess some very fertile lands, protected by well-built dikes from the inroads of the ocean. A million and a quarter acres are planted with cereals, the annual production being 34,000,000 bushels, of which amount one-third is oats, one-third rye, and the other third about equally divided between wheat, barley, and buckwheat. The importations of cereals exceed the exportations. From 67 to 104 million kilograms of rice are imported, and after being prepared about one-third is exported.

The colonies belonging to the Netherlands give this country a great commercial power. The exhibits of rice from the colonies were very fine.

The exhibits of cereals from the Netherlands were interesting, and included the grains, flour, rice, starches, and glucose.

Wheat is cultivated chiefly in the provinces of Zeeland, Guelderland, Limbourg, and in the southern part of Holland. The variety called Zeeland wheat is very fine. Rye is the principal cereal grown in Zeeland.

BELGIUM.

Belgium is not a large country, only 7,363,790 acres, yet it is very progressive in agricultural industries. The exhibits shown in Class 67 included chiefly barley and malt, wheat flour, and some excellent samples of rice and rice flour.

The climate and the soil of parts of Belgium are favorable to the production of good qualities of wheat, rye, and oats, but the crops are insufficient for home consumption.

The imports and exports of cereals except rice in 1888, were as follows:

Cereals.	Imports.	Exports.
	Kilograms.	*Kilograms.*
Wheat	819.903,641	198,197,576
Rye	143,150,646	72,177,590
Oats	279,390,027	76,893,143
Barley and malt	237,908,655	46,983,319

The milling industry is one of the most important industries of Belgium. There are more than four thousand mills in the country, half of which use wind as the motive power. The value of milled products is annually about $64,000,000.

The foreign trade in flour, starches, and other farinaceous preparations in 1888 was as follows:

IMPORTATIONS.

	Kilograms.		Kilograms.
Germany	12,709,386	Argentine Republic	1,634,610
England	1,450,148	Roumania	1,835,804
Brazil	135,826	Russia	7,024,094
United States of America	6,926,598	Sweden and Norway	984,308
France	16,901,044	Other countries	1,175,389
Hamburg	3,024,526		
Netherlands	21,305,347	Total	75,107,080

EXPORTATIONS.

	Kilograms.		Kilograms.
Germany	21,028,548	Italy	263,355
England	5,125,400	Netherlands	15,495,148
Denmark	5,028,720	Sweden and Norway	361,277
Spain	4,768,229	Other countries	1,304,747
France	41,586,596		
Grand Duchy of Luxembourg	808,350	Total	95,770,370

There is annually imported into Belgium, chiefly from the East Indies, about 90,000,000 kilograms of rice, nearly one-third of which is exported after having been prepared in the rice mills of the country.

SPAIN.

In Spain about 30,500,000 acres are cultivated with cereals, more than half of which is in wheat. There was not a very comprehensive exhibit of cereals from this country, though there were some interesting samples of wheat in several varieties, some rye, barley, rice, some of the fine white corn of Murcia, some good flour, macaroni, etc.

PORTUGAL.

Cereals are among the chief products of Portugal and occupy about 2,775,000 acres in wheat, corn, rye, oats, barley, and rice. There were eight varieties in this class. Several varieties of tender, hard, and semihard wheat were shown. The hard wheat is cultivated chiefly in the warmer, drier districts. Corn is the principal cereal of the country. The varieties grown are numerous, yet the crops do not nearly suffice for the needs of the inhabitants.

SWITZERLAND.

The annual yield of cereals in Switzerland is officially estimated at 300,000,000 kilograms, which is about half enough for home con-

sumption, the deficiency being imported from Germany, Hungary, and the provinces of the Danube. Wheat is cultivated on 400,000 acres, barley on 62,500 acres, and oats on 250,000. There were only six exhibits from Switzerland in Class 67. These included several preparations of cereals and food for invalids and children, one or two of which were good preparations in their way.

AUSTRIA-HUNGARY.

Austria-Hungary had seventeen exhibits of cereals, including samples of many varieties of grain, some fine grades of flour, and farinaceous products.

The soil produces grain of all kinds. There are three principal climatic regions: (1) The southern region, in which the olive groves extend to 46° 30′ north latitude; (2) the middle region extends to 48° 30′ and produces wheat and wine; (3) the northern region, north of 48° 30′, is favorable for cereal culture. Wheat is not cultivated above an altitude of 2,300 feet; rye not above 2,600 feet; barley, 2,800 feet; corn, 2,100 feet; potatoes, 4,000 feet; and oats, 4,200 feet.

About 27,580,000 acres are under cereal cultivation. The territories best suited to the cereals are the valley of the Danube, the plains of Salzbourg, the hills of Styrie, the valleys of the Elbe and of the Eger, the plains of Bukowine, the northeastern portion of Galicie, and a great part of Hongrie and Slavonie. The low lands of Bannat, and those of eastern Esclavonie, are also well adapted to the culture of cereals, as is also the plain situated between the Theiss and the Danube. The annual average yield of wheat is 49,683,000 hectoliters; oats, 38,986,000 hectoliters; barley, 18,230,130 hectoliters; oats, 52,282,000 hectoliters; and corn, 35,282,000 hectoliters.

Hungary produces twice more wheat and twice more oats than Austria proper. Corn is cultivated chiefly in the southern part of the empire. Hungary and Bohemia produce most of the wheat. Rice is cultivated in the district of Gradiska.

With the exception of wheat, Austria raises cereals enough for home consumption. Hungary in good years has a surplus of grain and flour for export. Barley is used in the form of pearl barley and malt. There are upwards of four thousand five hundred breweries. There are about fifty-eight thousand flour mills in Austria-Hungary, more than half of them being in Hungary. A third of the flour made is exported to England, Brazil, Switzerland, Holland, and the East Indies.

ROUMANIA.

Roumania is largely interested in the cultivation of cereals. The exhibits included wheat, corn, oats, rye, barley, and the smaller grains, some fine grades of flour, macaroni, vermicelli, and other pastes, and some starches.

SERVIA.

Servia had twelve exhibits of flour of excellent quality and some grain. The cereals cultivated in southern Servia are wheat, corn, rye, barley, and oats.

GREECE.

There were more than a hundred exhibits of cereals from Greece, including wheat, corn, barley, rye, millet, oats, and some macaroni, etc., the collection representing all the historic districts of the country.

ITALY.

In Italy 19,850,000 acres are planted in cereals, more than half of which is in wheat fields. The annual harvest of cereals is about 260,000,000 bushels, which, however, is not sufficient for home demand, the deficiency being imported from other European countries.

The exhibits of cereal products were limited to five nicely arranged exhibits of macaroni and other alimentary pastes for which the Italians are world-renowned.

Sicily and Sardinia produce hard and clean wheat, specially suited for making macaroni and vermecelli.

The manufacture of Italian pastes (macaroni, etc.) is of great importance in Liguria, Venice, and the Neapolitan provinces. They are exported to America, Austria, Turkey, and Egypt. The Neapolitan macaroni is made principally from flours known as saragollė. The exhibits of these pastes were attractive, and included very many varieties, from the yellow to those of snowy whiteness.

SAN MARINO.

The little republic of San Marino had one exhibit of grain.

RUSSIA.

The cereals constitute the principal agricultural production of Russia. Rye is very extensively cultivated and is one of the great staple foods of the people. The winter cereals occupy 75,320,000 acres, or about 30 per cent of the cultivated lands of the country, and the spring cereals occupy 85,585,000 acres, or about 33 per cent of such territory. More than 40 per cent of the worked land is in rye.

There was a remarkably fine exhibit of Russian grains and flour, among which may be specially mentioned some beautiful hard and tender wheat, and some white oats. From Turkestan there was some rice with black barbs, some white corn, and some very fine white sorghum.

The samples of flour indicated that very great progress has been made in the milling industry in Russia during the last decade. The starches and other secondary products were of good quality.

The harvests of grain in European Russia, Poland excepted, for the years 1885 to 1888, were as follows:

Grain.	1885.	1886.	1887.	1888.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Rye	708,000,000	666,000,000	750,000,000	732,000,000
Winter wheat	78,000,000	39,600,000	99,600,000	98,100,000
Spring wheat	100,800,000	122,400,000	180,600,000	158,400,000
Oats	391,200,000	570,000,000	621,000,000	552,000,000
Barley	100,800,000	134,400,000	169,200,000	141,600,000
Millet	24,000,000	64,500,000	52,500,000	47,520,000
Buckwheat	43,200,000	80,400,000	62,400,000	60,000,000

The exports of cereals from Russia in 1886, 1887, and 1888 were as follows:

Grain.	1886.	1887.	1888.
	*Poods.**	*Poods.**	*Poods.**
Wheat	79,335,000	118,617,000	133,927,000
Rye	59,948,000	72,710,000	99,501,000
Barley	33,192,000	48,353,000	65,270,000
Oats	33,763,000	59,666,000	86,804,000
Indian corn	19,694,000	26,514,000	15,836,000
Peas	1,335,000	3,517,000	5,840,000
Groats	598,000	1,367,000	2,266,000
Buckwheat	2,542,000	2,452,000	1,908,000
Divers grains	511,000	1,101,000	1,765,000
Wheat flour	2,538,000	2,422,000	2,684,000
Rye flour	963,000	1,303,000	1,157,000
Flour from divers cereals	182,000	80,000	63,000
Bran	3,957,000	5,941,000	12,473,000
Total	238,564,000	344,049,000	479,502,000

* One pood equals 36.1 pounds.

The value of the exports in 1887 was $123,032,000, and in 1886 it was $86,762,800.

The average price per bushel of the principal cereals in the markets of Russia in 1887 was as follows:

Winter wheat	$0.52
Spring wheat	.46
Rye	.33
Oats	.15
Barley	.23
Potatoes	.11

Finland exhibited some rye, barley, oats, also barley meal and oat meal. Much rye is exported to Sweden. Barley meal is a favorite food of Finlanders.

(3.) AFRICA.

ALGERIA.

The northwestern portion of Africa, of which Algeria forms the greater part, is renowned in history for the fertility of its soil, and also for the abundance and good quality of its cereals.

The average area cultivated and the average annual yield of the principal yields in Algeria during the eleven years from 1878 to 1888 were as follows:

	Hectares.	Metric quintals.
Tender wheat	179,928	1,306,789
Hard wheat	1,104,132	4,915,892
Rye	873	5,872
Barley	1,442,418	7,894,693
Oats	36,277	404,359
Corn	15,092	8[illegible],479
Aggregate	2,778,720	14,611,054
White sorghum	40,710	200,693

Formerly the Arabs cultivated only hard wheat, but now tender wheat is also quite extensively grown. The hard wheat is very rich in gluten, and so transparent that it is chiefly used for the manufacture of macaroni and other pastes. Barley is here of fine quality and is much sought for by the French and English brewers. White sorghum has been grown for a long time by the Arabs. Its grain is said to be very nutritious. The long millet of the Canaries is cultivated here and a considerable quantity annually exported.

The exports of cereals from Algeria in 1887 were as follows:

	Metric quintals.	Value.
		Francs.
Wheat	1,006,887	23,772,257
Rye	616,681	10,181,778
Barley	381,274	6,195,702
Oats	35,615	1,167,599

EGYPT.

Egypt is divided into Upper, Middle, and Lower Egypt, which last comprehends the delta of the Nile, and comprises an area of about 212,600 square miles, with a population of about 5,500,000. A great part of the country is a sandy waste, the cultivated land being confined to that portion affected by the annual inundation of the Nile. This magnificent river begins to increase in volume at the end of June. This growth is the result of rainfalls that begin in

March on the Abysinian plateaus. From the 10th to the 15th of August the river decreases in size, little by little, and reënters its bed at the end of September, or the beginning of October. Then the farmers commence work on the lands that have been inundated for a hundred days. A season of abundance or of scarcity depends on the extent of the rise of the Nile. Wheat, corn, barley, sorghum, rice, and some other cereals are cultivated over large areas. The African sorghum (doura) is the principal nourishment of the natives.

The annual production of cereals is about as follows:

	Metric quintals.
Wheat	4,020,000
Barley	2,700,000
Sorghum and corn	3,350,000
Rice	134,000

TUNIS.

Tunis had quite a complete exhibit of cereals. The kinds mostly cultivated are wheat, barley, corn, and rice.

SENEGAL.

Senegal, on the northwest coast of Africa, comprises a vast area of fertile lands and of desert plains. There are two seasons, the dry season, which lasts from December to the end of May, and the wet season, which commences in June and finishes at the end of November. The heat is excessive during the dry season. The cereals, especially rice and sorghum, are quite extensively cultivated.

REPUBLIC OF SOUTH AFRICA.

The South African Republic had exhibits of wheat, rye, barley, corn, oats, and several grades of flour.

CAPE VERDE ISLANDS.

The Cape Verde islands had some exhibits of flour from manioc, which, with sugar, coffee, and tobacco, form the principal agricultural products of these islands.

REUNION.

The exhibits of cereals from Reunion comprised an interesting collection of white corn, manioc, tapioca, rice, sago, and starches. Barley, oats, and wheat grow in this island, but not in great abundance.

CAPE COLONY.

In the Cape Colony the cereals occupy an area of about 500,000 acres, and the annual production is about 1,000,000 pounds of wheat, barley, rye, oats, corn, and sorghum. The agricultural exhibits of this country were not classified in Class 67.

(4.) Asia.

PERSIA.

Persia was awarded a silver medal for its small exhibit of cereals. Wheat of very fine quality grows in Persia, also barley, rice, and other cereals.

Wheat is exported to Russia and Turkey. Barley forms the chief food for cattle. Rice is one of the principal foods of the Persians.

JAPAN.

The areas of cereals under cultivation in Japan in 1885 were as follows: Rice, 6,401,197 acres; wheat, barley, and rye, 3,759,599 acres. The production of rice was 169,523,577 bushels, and of wheat, rye, and barley, 59,234,529 bushels. The exhibit from Japan showed fully the varied resources of the country. Besides the cereals in the grain, there were some excellent samples of starch and vermicelli. Rice was shown in great variety, and some saki or rice wine.

SIAM.

Siam was awarded a gold medal for its exhibit of rice, which is very extensively grown in that country.

BRITISH INDIA.

There were no exhibits of cereals from British India, except incidentally in connection with grain-importing houses of Europe. The growth of the wheat industry in India is discussed on a subsequent page under the general head of wheat.

FRENCH INDIA AND COCHIN CHINA.

French India had two exhibits of rice, and Cochin China showed some samples of the same cereal.

(5.) Oceanica.

AUSTRALASIA.

Victoria, Australia, made an excellent exhibit of many varieties of wheat, barley, oats, and corn, and some flour of good quality.

The cereal harvests in 1887 and 1888 were as follows:

	Wheat.	Oats.	Barley.
	Bushels.	*Bushels.*	*Bushels.*
1887..............	12,100,036	4,256,079	827,852
1888........	13,328,765	4,562,530	956,476

The wheat crop has more than doubled since 1877. The imports of breadstuffs in 1887 were 159,314 bushels, valued at £31,354, and the exports were 4,057,301 bushels, valued at £868,030.

New Zealand made a comprehensive display of cereal products, both in the grain and milled. The varieties of wheat and barley were numerous. The Auckland Roller Mills showed some "patent full-roller silk-dressed flour," and some "Lamb's patent porridge meal." The samples of barley and oats were also of the best quality. Some very fine wheats were exhibited, such as pearl wheat weighing 66½ pounds to the bushel; Tuscan wheat, 67 pounds; Tuscan white, purple straw, 69 pounds; and velvet chaff, 67 pounds. In 1887 there were 253,025 acres under wheat, which yielded 6,297,638 bushels, or 24.89 bushels per acre; 387,228 acres were sown with oats, and yielded 11,973,295 bushels, or 30.92 bushels per acre; and 27,683 acres produced 134,965 tons of potatoes. The exports of flour in 1886 were 8,698 tons, and of oatmeal 1,041 tons.

TAHITI.

Tahiti had a small exhibit of starches from arrowroot, manioc, and cocoa.

NEW CALEDONIA.

New Caledonia exhibited some corn, wheat, barley, rice, and other cereals, illustrating the possible resources of that colony.

HAWAIIAN ISLES.

From the Hawaiian Isles could be seen some samples of flour of taro.

III.—THE CEREALS.

1. Wheat.

Wheat was cultivated in China 3,000 years before the Christian era. It was known to the ancient Egyptians and the Greeks. The Romans at first cultivated only barley, but when they became masters of the world wheat was their principal food. In England, at the time of Julius Caesar, in ancient Gaul, and also among other ancient peoples of Europe, wheat was extensively cultivated. All the varieties of wheat are not grown in the same regions. In the northern countries of Europe, in Australia, and in some of the temperate parts of Spain, Portugal, Italy, and Africa, preference is given to tender grains. In the southern countries of Europe, in Algeria, and in Egypt they prefer the hard grains. Some soils yield wheat that is between the tender and hard varieties. The white wheat is the more esteemed because its flour is the whitest and makes the finest bread. The red or golden wheat gives a yellowish flour, but which has more body than the white sort. Wheat semihard,

gives flour much sought for by the pastry baker. Hard and flinty wheat is used chiefly for the preparation of macaroni, vermicelli, etc. The white, tender wheat contains not more than 10 to 11 per cent of gluten, the hard wheat from 16 to 18 per cent. Commercial wheats, known as "mottled," are mixed varieties. In general, southern Europe and the southern part of the United States yield wheat of small size and almost transparent flintiness, showing a preponderance of gluten. Canada, the northern and central parts of the United States, Russia, Germany, Norway, and Sweden yield larger and softer grains, indicating a preponderance of starch.

The annual production of wheat throughout the world is about 2,050,000,000 bushels, of which amount the United States produces 22 per cent, France 15 per cent, India 10 to 12 per cent, and Russia 12 per cent. Although the crop in Europe is nearly one-half the total yield in the world, it is not sufficient for the home demand, the deficiency being met by imports, chiefly from the United States and India. The only European nations that produce a surplus for exportation are Russia, Roumania, Bulgaria, Servia, and Austria-Hungary. All the other countries of Europe are obliged to purchase their supply from abroad.

The wheat crop of 1889 and the estimated importation and exportation of several countries is given by the Bulletin des Halles, Paris, September 9, 1889, as follows:

The wheat production of the world in 1889, *with estimates of the importation and exportation.*

	Production.	Importation.	Exportation.
Europe:	*Bushels.*	*Bushels.*	*Bushels.*
France	308,412,500	16,500,000	
Russia	206,250,000		77,000,000
Austria-Hungary	137,500,000		
Spain	123,750,000	5,500,000	
Italy	118,250,000	22,000,000	
Germany	90,750,000	24,750,000	
England	79,750,000	137,500,000	
Roumania and Bulgaria	41,250,000		13,750,000
Turkey in Europe	33,000,000		4,125,000
Belgium	16,000,000	12,375,000	
Portugal	8,250,000	2,750,000	
Servia	6,870,000		1,375,000
Holland	5,500,000	11,000,000	
Greece	5,500,000	2,200,000	
Sweden and Norway	5,500,000	2,475,000	
Denmark	4,125,000	1,375,000	
Switzerland	2,200,000	8,250,000	
Total	1,193,357,500	246,775,000	96,250,000

The wheat production of the world in 1889, *with estimates of the importation and exportation*—Continued.

	Production.	Importation.	Exportation.
	Bushels.	*Bushels.*	*Bushels.*
America:			
United States	481,250,000	....	126,500,000
Canada	33,000,000	....	8,250,000
Chile	12,375,000	....	2,750,000
Argentine Republic	12,375,000	....	1,925,000
Total	539,000,000	....	139,425,000
Asia:			
India	236,500,000	....	23,370,000
Asia Minor	35,750,000	....	2,750,000
Persia	22,000,000	....	2,750,000
Syria	12,375,0 0	....	1,375,000
Total	306,625,000	....	30,245,000
Africa:			
Algeria	22,000,000	....	4,950,000
Egypt	7,700,000	....	1,375,000
Total	29,700,000	....	6,325,000
Australia	27,500,000	....	1,375,000
General total	2,096,182,500	246,775,000	273,870,000

As official statistics of the wheat crop of all countries for any recent year are not on record, I give the estimates of some of the best authorities on this subject.

Wheat crop of the world in 1887, 1888. (*In hectoliters of* 2¾ *bushels.*)

[Bulletin des Halles, Paris.]

Country.	1887.	1888.	Country.	1887.	1888.
	Hectoliters.	*Hectoliters.*		*Hectoliters.*	*Hectoliters.*
United States	161,330,000	141,537,000	Manitoba	4,713,000	2,175,000
France	115,727,000	96,454,000	Argentine Republic	6,670,000	7,250,000
Russia	97,510,000	89,262,000	Holland	2,030,000	1,740,000
India	81,506,000	96,741,000	Denmark	1,653,000	1,450,000
Hungary	51,736,000	49,880,000	Greece	1,885,000	1,885,000
Austria	18,414,000	18,270,000	Roumania	11,600,000	13,050,000
Italy	42,340,000	37,700,000	Servia	1,885,000	2,175,000
United Kingdom	27,631,000	26,999,000	Sweden and Norway	1,160,000	1,160,000
Germany	26,250,000	31,900,000	Switzerland	725,000	725,000
Spain	29,000,000	23,838,000	Turkey	15,225,000	14,500,000
Portugal	2,900,000	2,900,000	Algeria	5,075,000	4,150,000
Belgium	8,062,000	6,090,000	Egypt	4,350,000	2,900,000
Australia	16,147,000	9,570,000	Chile	6,525,000	6,525,000
Canada	8,555,000	7,902,000	Total	763,627,000	699,131,000

NOTE.—Japan, which produces about 40,000,000 bushels, should be added to the above, and also China and some other eastern countries.

Wheat crop of the world in 1886.

[United States Department of Agriculture.]

	Bushels.
America:	
United States	457,218,000
Canada	37,219,234
Argentine Republic and Chile	28,800,625
Europe:	
Austria-Hungary	143,001,488
Belgium	18,514,688
Denmark	4,731,531
France	299,107,620
Germany	82,000,000
Great Britain and Ireland	65,285,353
Greece	4,937,250
Italy	129,412,133
Netherlands	4,937,250
Europe—Continued.	
Portugal	8,228,750
Roumania	22,629,063
Russia (including Poland)	213,907,084
Servia	4,525,813
Spain	131,660,000
Sweeden and Norway	4,081,115
Switzerland	1,645,750
Turkey	41,143,750
Australasia	22,258,146
India	258,317,632
Egypt	16,457,500
Algeria	32,915,000
Total	2,032,934,775

CANADIAN WHEAT.

Canada did not participate in the Paris Exposition, therefore no comparison could be made of Canadian wheat with the grain from other lands. An immense increase in the wheat industry followed immediately the general settlement of the province of Manitoba. In 1880 that province was little known; in 1881 there were 50,000 acres in wheat, and in 1884 more than 310,000 acres, and the crop bore 8,750,000 bushels. In Ontario 1,379,000 acres were cultivated with this cereal in 1871, and in 1882 more than 1,800,000 acres. The annual crop of Canada is now about 33,000,000 bushels.

WHEAT INDUSTRY IN THE UNITED STATES.

As stated on a previous page, the United States produces 22 per cent of the total wheat yield of the world. The production of our country in 1887 was 456,320,000 bushels, and the home consumption was 336,795,196 bushels, about 54,000,000 bushels being used for seed and the rest for food. The exports of wheat and wheat flour during the year ended June 30, 1887, were 120,127,664 bushels, or more than 26 per cent of the production and the imports were 593,860 bushels.

The price of wheat has varied greatly. In 1881 it reached $1.15 per bushel, while in 1884 it was only 80 cents. The exportation of wheat in the grain is decreasing and of wheat flour increasing, a result chiefly of improvements in methods of milling. These improvements have also enhanced the value of the spring wheat produced throughout the Northwest, especially in Minnesota and Dakota.

The great flour-milling center of the United States is Minneapolis, where were produced in 1888 more than 7,000,000 barrels of flour, valued at $35,000,000. Among other great milling centers are St. Louis, Richmond, and Baltimore.

The total output of the mills of the United States each year is about 75,000,000 barrels. The very superior grades of flour exhibited

by the Minneapolis mills attracted the earnest attention of European millers, and the immense amount of work accomplished by those mills surprised all foreigners.

The detailed statistics of the production of wheat in the United States and of the extent of our foreign trade are fully set forth in the following tables prepared by the Bureau of Statistics of the Treasury Department.

Quantity of wheat produced, and of wheat and wheat flour imported, exported, and retained for consumption in the United States. from 1867 *to* 1888, *inclusive.*

Calendar year.	Production.	Year ending June 30—	Imports.	Total production and imports.	Exports domestic and foreign.	Retained for home consumption.	Consumption per capita.	Percentage exported.
	Bushels.		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bush.*	
1867	212,441,400	1868	2,014,328	214,455,728	26,564,607	187,891,121	5.08	13.39
1868	224,036,600	1869	1,830,393	225,866,993	30,143,987	195,733,006	5.18	13.35
1869	260,146,900	1870	1,285,676	261,432,876	54,411,735	207,021,141	5.37	20.81
1870	235,884,700	1871	867,489	236,752,189	53,068,920	183,683,269	4.64	22.42
1871	230,722,400	1872	2,410,738	233,133,138	39,997,265	193,135,873	4.76	17.16
1872	249,997.100	1873	1,841,049	251,838,149	52,545,731	199,292,418	4.78	20.86
1873	281,254,700	1874	2,116,777	285,371,477	92,534,779	190,836,698	4,46	32.65
1874	309,102,700	1875	367,987	309,470,687	73,212,614	236,258,073	5.38	23.66
1875	292,136,000	1876	1,664,138	293,800,138	76,171,643	217,628,495	4.82	25 93
1876	289,356,500	1877	366,061	289,722,561	57,513,589	232,208,972	5.01	19.85
1877	364,194,146	1878	1,390,713	365,584,859	93,419,031	272,165,828	5.71	25.55
1878	420,122,400	1879	2,068,018	422,190,418	149,508,553	272,681,865	5.58	35.41
1879	448,756,630	1880	486,106	449,242,736	180,934,478	268,308,258	5.35	40.28
1880	498,549,868	1881	211,402	498,761,270	186,475,251	356,486,785	6.58	37.39
1881	382,280,099	1882	865,467	381,145,557	122,597,997	258,547,560	4.90	32.17
1882	504,185,470	1883	1,087,011	505,272,481	148,785,696	312,286,019	6.07	29.45
1883	421,086,160	1884	32,474	421,118,634	111,636,302	309,482,332	5.42	16.79
1884	512,765,000	1885	212,311	512,976,211	132,851,835	380,124,376	6.66	25.89
1885	357,112,000	1886	388,415	357,500,415	94,913,395	262,587,020	4.49	26.55
1886	457,218,000	1887	282,400	457,500,400	154,163,415	303,336,985	5.07	33.70
1887	456,329,000	1888	593,860	456,92[illegible],860	120,127,664	336,795,196	5.47	26.29

Quantity of wheat and wheat flour exported from the United States from 1863 *to* 1888, *inclusive.*

Year ending June 30—	COUNTRIES TO WHICH EXPORTED.							
	Belgium.		Brazil.		France.		Germany.	
	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.
	Bushels.	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*
1863	622,986	12,828	....	408,820	403,679	21,418	38,479	4,512
1864	78,270	15,997	....	407,974	292,424	15,709	99,827	8,939
1865	85,885	12,172	....	366,840	17,329	5,558	....	84
1866	....	55	....	296,144	....	80	....	321
1867	....	1,004	2,697	166,353	41,436	....	....	682
1868	34,726	7,894	....	247,645	260,763	12,008	....	1,068
1869	5,016	3,404	10,211	384,134	36,839	159	21,961	1,647
1870	195,964	15,144	....	376,217	1,012,637	34,271	317,289	7,898
1871	942,399	60,433	....	455,673	555,263	47,521	149,214	1,798
1872	1,275,101	4,341	....	382,216	1,429,688	247	290,737	3,364
1873	100,054	305	1,800	408,648	....	31	164,474	3,795
1874	3,709,694	72,401	4,999	531,379	2,223,366	7,260	886,485	21,910
1875	2,981,744	19,418	11	599,832	127,009	1,020	373,818	7,929
1876	2,190,282	22,806	....	536,180	521,041	19	516,156	14,113
1877	1,410,610	13,325	3	482,209	874,642	140	990,067	10,874
1878	3,633,778	16,933	52,523	616,132	4,337,091	445	33,573	8,261
1879	9,037,297	44,437	....	717,377	42,147,558	27,075	442,242	11,233
1880	13,418,016	49,261	....	537,914	43,601,291	9,933	1,223,279	11,911
1881	15,384,500	182,545	18,201	677,702	29,440,418	46,396	3,029,232	17,373
1882	8,855,842	55,748	109	618,908	11,225,848	4,579	480,600	4,893
1883	10,290,564	119,869	47,410	739,441	15,096,712	63,223	1,405,999	33,645
1884	6,808,449	140,272	....	649,017	8,385,155	11,996	886,096	34,062
1885	8,287,470	138,405	23,861	674,230	8,565,129	2,034	745,561	32,398
1886	4,842,934	30,044	4,995	542,499	2,014,404	98	356,352	10,532
1887	10,498,727	166,414	41,913	748,937	19,546,090	435	888,857	43,499
1888	5,925,077	160,524	149	584,670	4,212,947	8,528	768,429	45,912

Quantity of wheat and wheat flour exported from the United States, etc.—Continued.

Year ending June 30—	COUNTRIES TO WHICH EXPORTED.							
	Great Britain and Ireland.		British Possessions in North America.				British West Indies, British Honduras, and British Guiana.	
			Provinces of Quebec and Ontario.		All other.			
	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.
	Bushels.	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*
1863	27,325,739	1,794,496	*a*	*a*	6,583,695	964,441	*b*8,441	*b*400,987
1864	18,078,999	979,754	*a*	*a*	4,116,543	865,986	*b*7,839	*b*127,177
1865	5,823,255	400,072	3,728,929	120,606	33,662	617,434	10,311	441,008
1866	1,970,719	136,020	1,851,300	50,334	74,393	773,621	4,614	329,489
1867	4,685,615	116,299	798,550	19,342	12,842	289,209	530	297,309
1868	12,368,446	484,706	3,056,271	46,371	12,882	340,112		296,611
1869	13,356,550	407,082	3,358,597	347,198	24,680	155,481	1,560	331,875
1870	27,787,609	1,188,951	6,232,357	316,901	26,776	215,359	5	419,456
1871	22,488,021	1,227,624	9,252,149	445,509	88,029	221,333	17,361	400,938
1872	19,017,411	328,544	3,709,065	338,032	2,477	192,056		421,963
1873	31,790,876	531,801	*c*6,304,042	*c*70,966	2,798	364,469	28,926	433,302
1874	51,833,278	1,703,984	*c*8,717,903	*c*93,116	3,400	348,410		422,198
1875	42,057,004	1,231,324	*c*5,018,894	*c*133,924	14,087	450,461	4,813	479,153
1876	42,256,652	1,335,185	*c*5,520,304	*c*159,991	10,333	378,250	4,256	535,803
1877	31,202,296	918,283	*c*4,121,102	*c*257,319	21,322	383,482	1,010	429,198
1878	54,664,732	1,615,479	*c*5,666,201	*c*122,840	12,906	300,491	32,500	445,269
1879	57,419,292	2,529,665	*c*5,187,373	*c*136,882	16,660	368,038	14,924	508,740
1880	79,068,075	3,645,952	*c*7,918,457	*c*56,138	1,791	221,528	700	459,558
1881	82,550,921	4,610,415	*c*8,369,515	*c*230,627	403,478	247,258	345	588,238
1882	65,600,582	3,289,909	*c*2,887,900	*c*136,084	276,071	236,994	2,503	477,155
1883	65,266,803	5,717,429	*c*5,110,974	*c*252,198	220,961	306,877	3,252	508,240
1884	44,761,690	5,583,843	*c*4,370,400	*c*495,367	10,587	354,817	1,009	545,721
1885	56,522,002	6,807,528	*c*3,442,118	*c*511,724	22,156	304,246	1,016	563,123
1886	40,678,739	4,914,782	*c*2,487,572	*c*312,449	19,923	194,848	2,045	587,081
1887	54,352,915	7,632,071	*c*4,668,282	*c*378,046	10,887	172,652	1,064	527,053
1888	41,322,300	8,070,490	*c*4,517,858	339,040	6,991	233,121	2,311	622,056

a Included in "all other British Possessions in North America."
b Embraces "British West Indies and Possessions in Central and South America."
c Includes "Manitoba and the Northwest Territory."

Quantity of wheat and wheat flour exported from the United States, etc.—Continued.

Year ending June 30—	COUNTRIES TO WHICH EXPORTED.							
	Haiti and Santo Domingo.		Portugal.		Cuba.		Porto Rico.	
	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.
	Bushels.	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Barrels.*
1863	....	136,112	*a* 583,083	*a* 56,992	*b* 4,807	*b* 32,502	*c*........	*c*........
1864	....	128,624	*a* 82,104	*a* 15,885	*b* 42,926	*b* 59,568	*c*........	*c*........
1865	....	150,604	90,282	15,370	60,270	27,785	500	26,884
1866	....	85,825	83,794	25	....	38,064	161	15,829
1867	....	41,020	4,800	....	....	10,545	....	3,133
1868	....	61,339	83,190	29,540	560	104,418	....	49,574
1869	....	38,412	120,880	6,530	7,450	143,531	....	77,309
1870	......	64,165	701,825	13,678	24,495	149,183	....	67,803
1871	....	67,677	475,856	8,509	....	189,027	....	65,824
1872	....	72,845	426,884	4,648	110	164,146	....	65,706
1873	....	110,029	131,129	1,970	25,403	92,532	....	41,407
1874	....	160,248	300,301	886	5	199,427	....	46,233
1875	....	194,467	1,595,014	11,941	....	127,247	....	60,097
1876	....	186,273	1,412,988	12,8 5	....	91,050	....	46,510
1877	....	135,272	1,013,302	8,270	400	91,122	....	42,655
1878	....	122,814	2,178,366	16,612	....	21,022	....	20,396
1879	....	140,253	3,174,611	18,588	600	121,272	....	47,434
1880	....	106,720	2,196,724	4,829	20	101,326	22,200	56,520
1881	....	195,725	2,493,418	12,698	9	80,679	....	46,261
1882	....	110,096	2,508,364	6,077	26,260	56,955	407	40,038
1883	....	121,223	3,490,560	3,627	46,323	237,915	4,002	75,327
1884	....	103,525	3,355,292	4,465	3,916	152,351	250	76,017
1885	....	117,614	3,763,826	11,126	805	194,250	....	78,534
1886	3,408	134,997	3,552,850	7,472	123	198,464	....	96,833
1887	....	111,786	4,011,406	21,723	181	217,160	....	108,503
1888	8	162,990	4,276,519	42,493	150	282,548	....	134,549

Quantity of wheat and wheat flour exported from the United States, etc.—Continued.

Year ending June 30—	COUNTRIES TO WHICH EXPORTED.					
	Gibraltar.		All other countries and ports.		Total.	
	Wheat.	Wheat flour.	Wheat.	Wheat flour.	Wheat.	Wheat flour.
	Bushels.	*Barrels.*	*Bushels.*	*Barrels.*	*Bushels.*	*Bushels.*
1863	*d*	*d*	589,505	556,844	36,160,414	4,390,055
1864	*d*	*d*	882,780	631,734	23,681,712	3,557,347
1865		8,927	87,363	447,954	9,937,876	2,641,298
1866		2,454	1,594,125	454,789	5,579,103	2,183,050
1867		500	599,941	354,710	6,146,411	1,300,106
1868		15,328	124,061	379,809	15,940,899	2,076,423
1869		12,840	614,092	522,271	17,557,836	2,431,873
1870		7,132	285,158	587,175	36,584,115	3,463,333
1871	1,780	12,106	340,825	449,869	34,310,906	3,653,841
1872		1,277	271,607	535,150	26,423,080	2,514,535
1873		122	654,783	502,709	39,204,285	2,562,086
1874	900	2,454	3,359,597	484,188	71,039,928	4,094,094
1875	1,500	2,088	1,773,283	654,227	53,047,177	3,973,128
1876	233,919	1,270	2,407,191	615,177	55,073,122	3,935,512
1877	4,796	877	686,061	570,639	40,325,611	3,343,665
1878	98,352	4,948	1,694,933	635,691	72,404,961	3,947,333
1879	216,178	48,697	4,717,201	810,023	122,353,936	5,629,714
1880	404,990	6,543	5,397,252	743,886	153,252,795	6,011,419
1881	390,556	14,278	8,484,875	995,591	150,565,477	7,945,786
1882	101,396	5,150	3,305,920	873,100	95,271,802	5,915,686
1883	103,916	14,116	5,298,352	1,012,534	106,385,828	9,205,664
1884	4,100	3,787	1,762,068	997,020	70,349,012	9,152,260
1885	994	21,821	3,568,776	1,191,102	84,653,714	10,648,145
1886	340,656	6,817	3,445,208	1,142,326	57,759,209	8,179,241
1887	132,106	8,150	7,849,521	1,382,020	101,971,949	11,518,449
1888		4,357	4,756,527	1,272,296	65,789,261	11,963,574

a Embraces "Portugal and Portuguese colonies."
b Embraces all "Spanish West Indies."
c Included in "Cuba."
d Included in "All other countries."

WHEAT IN SOUTH AMERICA.

Uruguay showed some samples of wheat of good appearance. The annual crop of this country is from 2,500,000 to 3,500,000 bushels.

Ecuador showed some specimens of wheat and other cereals.

Chile exhibited wheat in considerable variety, and some flour. According to the official catalogue of Chile, the annual wheat crop is estimated at 27,000,000 bushels, and the crop of other cereals at 8,250,000 bushels. The exportation of wheat and wheat flour in 1888 was 5,500,000 bushels. The above figures indicate a very great growth of this industry during the last few years.

At the beginning of the present century, wheat was successfully cultivated in some of the provinces of Brazil, but a malady called "la rouille" made such ravages that the culture was nearly abandoned. Some new trials are now being made, but at present the country is a purchaser rather than a producer of this cereal, receiving the grain from the United States, Australia, and Europe, and manufacturing excellent grades of flour, samples of which were shown at the Exposition. A large mill at Rio Janeiro has facilities for grinding upwards of 200 tons of wheat per day.

The Argentine Republic made a very fine display of her cereal products. There were samples of wheat of several varieties. The cultivation of this grain has greatly increased during the last ten years and the annual crop is about 13,000,000 bushels.

Wheat could be grown in parts of Paraguay, but there is little cultivation of this cereal because of the low price of wheat and flour imported from the Argentine Republic.

WHEAT IN GREAT BRITAIN.

The chief wheat-importing country of the world is Great Britain. By examining the source of supply of the British markets, we have a good-idea of the producing centers of the world.

Imports of wheat and wheat flour into the United Kingdom in 1889.

a. WHEAT.

	Cwt.		Cwt.
Russia	21,321,628	Chile	572,953
Germany	2,538,629	British India	9,217,332
France	126,440	Australasia	1,406,060
Turkey	667,372	British North America	1,168,320
Roumania	2,862,487	Other countries	1,379,650
Egypt	325,150		
United States	17,016,250	Total	58,602,271

b. WHEAT MEAL AND FLOUR.

	Cwt		Cwt.
Germany	1,155,189	British North America	1,168,892
France	90,613	Other countries	378,565
Austrian Territories	1,838,115		
United States	10,067,827	Total	14,699,201

Imports of wheat and wheat flour into the United Kingdom 1879 to 1888.

	Cwt.		Cwt.
1879	73,002,110	1884	66,175,282
1880	68,459,814	1885	81,289,915
1881	71,344,659	1886	65,797,756
1882	80,562,503	1887	73,841,230
1883	84,550,271	1888	74,137,707

The value of the imports in 1887 was $156,500,000, and in 1888, $157,500,000. For the period from 1872 to 1884 the United States furnished 51.1 per cent (more than half) the total wheat purchased by the United Kingdom, and in 1887 the proportion was 62.1 per cent. Russia in 15 years averaged 13.6 per cent; India, 7.9 per cent; Australasia, 3.9 per cent.

The average annual imports of wheat from 1872 to 1886 were 121,256,572 bushels, of which the United States furnished 61,977,122 bushels; Russia, 16,466,109 bushels; India, 9,568,543, and Australasia, 4,687,304 bushels.

WHEAT INDUSTRY IN FRANCE.

The present annual wheat crop of France is 110,000,000 hectoliters, or 302,500,000 bushels. This amount, however, does not suffice for the home demand, and there is an annual excess of importation over exportation, averaging 35,000,000 bushels. I give below statistics of production and foreign trade for nearly 60 years. The flour exported is reduced to weight in grain at the rate of 70 kilograms of flour to 100 kilograms of wheat, the weight of a hectoliter of wheat being estimated at 75 kilograms.

Production of wheat in France, from 1831 *to* 1889, *with importations and exportations.—Official Statistics.*

[Hectoliter = 2¾ bushels].

Season.	Quantities harvested.	Wheat (flour included).		Season.	Quantities harvested.	Wheat (flour included).	
		Importations.	Exportations.			Importations.	Exportations.
	Hectoliters.	*Hectoliters.*	*Hectoliters.*		*Hectoliters.*	*Hectoliters.*	*Hectoliters.*
1888-'89	96,430,000	18,900,000	312,550	1859-'60 ...	87,545,960	1,401,159	8,177,329
1887-'88 ...	112,456,107	12,141,511	126,551	1858-'59 ...	109,989,747	1,828,984	6,455,271
1886-'87	107,2[illegible]9,682	13,906,984	159,448	1857-'58 ...	110,426,462	3,885,000	403,159
1885-'86	110,277,405	6,578,[illegible]63	249,821	1856-'57 ...	85,308,953	8,773,392	168,681
1884-'85	114,230,977	14,736,240	29[illegible],363	1855-'56 ...	72,936,726	3,677,759	192,657
1883-'84	103,753,426	13,175,644	259,604	1854-'55 ...	97,194,271	5,570,410	252,106
1882-'83	122,153,524	15,505,727	363,623	1853-'54 ...	63,709,038	4,781,658	1,048,350
1881-'82	96,810,356	17,585,010	433,275	1852-'53 ...	86,065,386	267,953	2,359,479
1880-'81	99,471,559	27,200,473	407,753	1851-'52 ...	85,986,232	102,544	4,857,356
1879-'80	79,355,866	29,788,434	439,044	1850-'51 ...	87,986,788	842	4,345,[illegible]87
1878-'79	95,270,698	18,639,746	820,233	1849-'50 ...	90,761,712	4,502	2,959,710
1877-'78	100,145,651	4,650,781	5,175,307	1848-'49 ...	87,994,435	1,250,057	1,924,896
1876-'77	95,439,832	7,119,291	3,372,014	1847-'48 ...	97,611,140	10,095,484	196,515
1875-'76	100,634,861	4,713,210	6,556,319	1846-'47 ...	60,696,968	4,914,229	244,546
1874-'75	133,130,163	10,939,867	2,2[illegible]0,805	1845-'46 ...	71,963,280	748,905	436,586
1873-'74	81,892,667	6,923,954	2,972,090	1844-'45 ...	82,454,845	2,475,162	3[illegible]6,951
1872-'73	120,803,459	5,659,326	4,157,202	1843-'44 ...	73,650,509	2,024,893	287,341
1871-'72	69,276,419	13,925,446	154,513	1842-'43 ...	71,314,220	562,573	658,500
1870-'71	....	....	....	1841-'42 ...	71,463,683	156,[illegible]41	854,168
1869-'70	107,941,553	1,849,905	885,029	1840-'41 ...	80,[illegible]80,431	2,240,734	201,092
1868-'69	116,783,000	11,073,245	680,680	1839-'40 ...	64,935,732	1,178,101	784,494
1867-'68	83,005,739	9,249,718	573,920	1838-'39 ...	67,743,571	100,685	650,570
1866-'67 ...	85,131,455	838,732	6,861,025	1837-'38 ...	67,915,534	285,132	469,578
1865-'66	95,571,609	342,98[illegible]	4,779,199	1836-'37 ..	62,583,725	220,504	310,556
1864-'65	111,274,018	813,904	2,057,214	1835-'36 ...	71,697,684	459	273,386
1863-'64	116,781,794	2,469,068	829,534	1834-'35 ...	61,981,226	456	264,157
1862-'63	99,292,224	6,288,949	563,086	1833-'34 ...	66,073,141	6,323	232,913
1861-'62	75,116,287	13,696,148	1,230,113	1832-'33 ...	80,089,016	4,463,146	223,058
1860-'61	101,573,625	729,124	4,822,889	1831-'32 ...	56,129,694	1,138,320	259,413

The importations are drawn chiefly from Russia, United States, Algeria, and India.

Imports of wheat for consumption in France, 1885, 1886, 1887.

[Quintal = 100 kilograms = 220 pounds.]

From—	1885.	1886.	1887.
	Quintals.	*Quintals.*	*Quintals.*
England	6,266	10,239	14,548
Belgium	120,638	96,809	35,972
Russia	1,856,995	1,700,450	1,973,662
Germany	30,249	24,690	12,672
Italy	7,723	731	75
Roumania	123,989	151,595	279,850
Turkey	611,378	352,044	258,710
British India	787,160	960,967	638,934
Australasia	383,269	34,258	134,453
Algeria	958,463	1,182,947	1,087,315
United States:			
Atlantic ports	1,084,342	2,031,957	3,283,988
Pacific ports	405,869	476,812	865,163
Other countries	81,525	74,007	381,552
Total	6,457,861	7,097,486	8,966,714

From a report of United States Consul Rathbone, of Paris, the following statistics are taken:

The consumption of wheat in France has increased much more rapidly than the population, because the bread made of wheat is taking the place of the bread made of rye, barley, oats, and buckwheat that formerly served as a principal article of food in many parts of France. Mr. Blaise, a French economist, has made the following calculations relative to the comparative consumption of wheat in France from 1821 to 1830 and from 1870 to 1880:

Description.	1821 to 1830.	1870 to 1880.
Quantity of wheat harvested annually ... Quintals..	44,542,527	74,132,009
Excess of importations over exportations ... do....	260,060	7,800,732
Total	44,802,587	81,932,741
To deduct for seed ... Quintals..	7,436,828	10,412,714
Remainder for consumption ... do....	37,365,759	71,520,027
Population of France	31,515,000	36,898,000
Average consumption per head:		
Per annum ... kilograms..	118.5	193
Per day ... grams..	324.0	530

Thus, in 50 years the ration of bread or of wheat of the French people has increased by 63 per cent.

In taking account of the inferior kinds of grains other than wheat utilized in making bread, Mr. Blaise finds per head and per day 377 grams in 1821 to 1830, and 563 in 1870 to 1880, making an augmentation of 49 per cent in quantity, coinciding with a notable amelioration in quality.

Price of wheat per hectoliter, in francs and centimes, in France, 1756 *to* 1888.

[Hectoliter = 2¾ bushels; franc = 19¼ cents.]

Years.	Years.	Years.	Years.	Years.	Years.	Years.	Years.
1888...18.65	1872...22.90	1856...30.75	1840...21.84	1824...16.22	1808...16.67	1786...14.12	1770..18.85
1887...18.13	1871...26.65	1855...29.32	1839...22.14	1823...17.52	1807...18.60	1785...14.89	1769..15.41
1886 ..16.94	1870...20.48	1854...28.82	1838...19.51	1822...15.49	1806...20.00	1784...15.35	1768..15.53
1885...16.80	1869...20.21	1853...22.39	1837...18.53	1821...17.79	1805...20.22	1783...15.07	1767..14.31
1884.. 17.76	1868...26.08	1852...17.23	1836...17.32	1820...19.13	1804...18.36	1782...15.29	1766..13.29
1883...19.16	1867...26.02	1851...14.48	18 5...15.25	1819...18.42	1803...22.88	1781...13.47	1765..11.18
1882...21.51	1866...19.59	1850...14.32	1834...15.25	1818...24.65	1802...25.14	1780...12.62	1764..10.03
1881...22.28	1865...16.94	1849...15.37	1833...16.62	1817...36.16	1801...22.19	1779...13.61	1763.. 9.53
1880...22.90	1864...17.80	1848...16.65	1832...21.85	1816...28.31	1800...20.34	1778...14.70	1762.. 9.94
1879...21.92	1863...19.78	1847...29.01	1831...22.10	1815...19.53	1799...16.20	1777...13.38	1761..10.00
1878...23.08	1862...23.24	1846...24.05	1830...22.39	1814...17.73	1798...17.07	1776...12.94	1760..11.79
1877...23.42	1861...24.55	1845...19.75	1829...22.59	1813...22.82	1797.. 19.48	1775...15.93	1759..11.79
1876...20.64	1860...20.24	1844...19.75	1828...22.03	1812...33.00	1790...19.48	1774...14.60	1758..11.29
1875...19.38	1859...16.74	1843...20.46	1827 ..18.21	1811...26.33	1789...21.90	1773...16.48	1757..11.91
1874...24.31	1858...16.75	1842...19.55	1826...15.85	1810...20.26	1788...16.12	1772...16.68	1756.. 9 58
1873...25.70	1857...24.37	1841...18.54	1825...15.74	1809...15.17	1787...14.18	1771...18.19	

SPANISH WHEAT.

The exhibits of grain from Spain were few in number. There were shown samples of both tender and hard wheat, which in appearance compare well with the best grains from other lands. The region of central Spain produces most of the wheat.

WHEAT IN PORTUGAL.

Portugal produces principally hard wheat, though the tender grain is also cultivated. The latter variety is common to the central and southern portions of the country, while the hard wheat is raised in the northern provinces. The annual production is about 9,000,000 of bushels, which is not sufficient for the needs of the inhabitants, and the importations are about 1,500,000 bushels.

WHEAT IN SERVIA AND ROUMANIA.

Wheat in southern Servia is, in general, of good quality. It is cultivated principally in the valleys of Nischava and of Morava. In Dobriski they raise the hardest and best wheat. The average price from 1883 to 1888 was $2.50 per 100 kilograms. There is annually exported about half a million kilograms of wheat.

Roumania grows both hard and tender wheats, but the climate is best suited to the hard variety, which is of very fine quality. The crop in 1886 was 57,254,487 bushels. The flour mills of Roumania number 4,941, of which 3,188 use water power, 450 steam, and 876 wind. They employ 10,000 workmen and produce $14,000,000 worth of wheat and other flours each year.

WHEAT IN ITALY.

Italy does not produce enough wheat for its own consumption, but the species cultivated there are of fine quality. From the *grano gentile* and *carosella* they make bread light and very white. The hard wheats are used chiefly in making semolinas and macaroni. There was no exhibit of wheat from this country. The wheats of Sicily and Naples are of remarkably good quality

WHEAT IN GREECE.

Greece produces only a limited amount of wheat. There was, however, a display of numerous samples of hard wheats. The annual production of about 4,125,000 bushels is not sufficient for the needs of the people, and a further supply is imported from Austria, Turkey, and Russia.

GERMAN WHEAT.

Germany made no exhibit of wheats nor of any other products. The annual wheat crop is about 90,000,000 bushels, and about 25,000,000 bushels in addition are imported to supply the home demand.

WHEAT IN AUSTRIA-HUNGARY.

Austria-Hungary made an exhibit of the products of the mills at Budapest and some other places. The flour was of fine quality. This country is a very important one in cereal productions, raising annually more than 60,000,000 hectoliters of wheat. Winter wheat is much more cultivated than spring wheat. The grain is of good quality, but is much inferior to the beautiful grain of northern Russia. The wheat of Banat is the finest in Hungary.

WHEAT IN BELGIUM.

Belgium had but few samples of wheat in the grain, though there were a number of good exhibits of flour, macaroni, etc. In 1888 the area in wheat culture in Belgium was 689,827 acres.

The production of wheat is about 432,000,000 kilos, a quantity insufficient even for the supply of the mills, which annually need 1,065,000,000 kilos. There is, therefore, an importation of 663,000,000 kilos, which comes chiefly from Russia, Roumania, the United States, and the East Indies.

RUSSIAN WHEAT.

Russia exhibited some samples of excellent wheat, grown chiefly on the extensive "black lands" region that extends from Poland far into Siberia. Russia has become a powerful rival of the United States in the wheat markets of Europe, and any attempt of American

merchants to unduly enhance the market price of this great food staple is promptly met by Russia, and often results in driving America from the field. There appears to be scarcely any limit to the undeveloped resources of Russia; with her vast agricultural domain she can, if necessary, feed the world.

The culture of winter wheat is that which predominates in the western part of Russia. Spring wheat is more widely grown in the southeastern portion, which include the "steppes," where the summers are warm and the winters cold and without snow. These two wheats are also cultivated in the southern districts, in the neighborhood of the Black Sea.

The harvest of winter wheat in 1888 was 98,100,000 bushels, and of spring wheat 158,400,000 bushels. The wheat exports in 1888 were 80,579,000 bushels, and of wheat flour 96,892,000 pounds. More than one-third of the exports go to England. The distribution of the exports of 1887 was as follows:

	Bushels.		Bushels.
United Kingdom	29,000,000	Spain	2,239,800
Italy	13,540,000	Turkey	1,839,000
France	9,250,000	Belgium	1,093,600
Germany	7,550,000	Other countries	97,550
Holland	6,474,000		
Greece	4,282,200		78,392,000
Austria-Hungary	3,043,850		

The average prices of wheat in the markets of Russia in 1886 and 1887 were as follows:

Markets.	Kind and quality.	Unit.	Price. 1887.	Price. 1886.
St. Petersburg	Saxony	Per bushel	$0.79	$0.76
	Samara	....do	.64	.71
Rybinsk	Kouban, first quality	....do	.92	.91
	Kouban, second quality	....do	.76	.77
	Saxony	....do	.72	.68
	Samara	....do	.60	.60
Odessa	Winter	Per 36 pounds	.44	.44
	Sandomir	....do	.46	.43
	Girk	...do	.44	.43
Warsaw	Sorted	....do	.47	.43
	Middling	....do	.45	.39
	Ordinary	....do	.42	.35

TURKISH WHEAT.

Turkey is a wheat-producing and exporting country. The immense extent of the Turkish Empire, including a great variety of climate and of soil, permits the culture of all kinds of wheat, from the hard and flinty grain to the beautiful white species.

AFRICAN WHEAT.

Algeria exhibited numerous samples of hard and tender wheats of excellent quality. The cultivation of this grain has considerably increased during the past 10 years, as appears by the following statistics:

Year.	Tender wheat.	Hard wheat.	Year.	Tender wheat.	Hard wheat.
	Metric quintal.	*Metric quintal.*		*Metric quintal.*	*Metric quintal.*
1878	997,147	3,952,043	1884	1,649,415	6,833,194
1879	1,213,058	4,347,616	1885	1,137,307	5,476,520
1880	1,405,315	5,425,003	1886	1,239,564	5,425,043
1881	585,804	3 564,238	1887	1,100,072	4,673,960
1882	1,537,320	5,065,533	1888	1,424,067	4,055,837
1883	1,179,613	5,256, 24			

Three-fourths of a quintal = hectoliter = 2¾ bushels.

The culture of wheat is one of the most important sources of wealth in Egypt. They cultivate much hard wheat, and also a variety of tender wheat. In Upper Egypt there is the Taouety wheat, sought by the bakers.

The Republic of South Africa made an exhibit of wheat grown in that country, and also flour produced in the mills at Pretoria and Ventersdorp.

EAST INDIA WHEAT.

The principal varieties of wheat grown in India are white, red, tender, and hard. The crop in 1885 was 290,000,000 bushels; in 1886 it was 258,000,000 bushels, and in 1888 it was 266,882,112 bushels cultivated on 26,854,822 acres. One-tenth of the crop is exported chiefly to Europe.

In British India wheat is cultivated chiefly in the northern provinces and in the valley of the Himalaya Mountains. Great quantities are exported. The wheat contains from 60 to 70 per cent. of starch, and from 8 to 12 per cent. of gluten.

AUSTRALIAN WHEAT.

Australasia, which includes the several colonies in Australia, also Tasmania and New Zealand, covers 3,075,238 square miles, and had a population of 3,426,562 in 1886. In 1883 there were 3,697,954 acres under wheat cultivation, and the production (a year of great abundance), was 45,541,592 bushels, a surplus of 9,000,000 bushels available for export.

Production of wheat in 1883.

	Bushels.
New South Wales	4,345,437
Queensland	42,842
South Australia	14,649,230
Western Australia	373,984
Victoria	15,570,245
Tasmania	732,718
New Zealand	9,827,136

Australia produces some tender wheat, superior in quality and firmness to the finest grains of France and England. The finest varieties are the "Tuscan" and the "Australian."

(2) RYE.

The annual production of rye in the world averages 1,375,000,000 bushels. Europe supplies 98 per cent of the total crop. In Russia, Austria-Hungary, and Germany, rye bread is the principal food of the inhabitants. The average rye crop of the principal countries, is as follows:

Rye crop of the world.

	Bushels.
Russia (including Poland)	715,000,000
Germany	244,000,000
France	79,00 ,000
Austria-Hungary	107,000,000
Belgium	16,500,000
United States	25,000,000
Canada	2,750,000

Rye bread stands next in importance to wheat. When well made it has an agreeable taste and keeps fresh for a long time. Wheat and rye flours are frequently mixed in bread-making.

The varieties mostly cultivated are "Autumn rye," "March rye," and "St. John rye." Superior qualities weigh 64 pounds to the bushel, but the average is not more than 60 pounds. The mixture of rye and wheat grown in France, Belgium, and Switzerland is called méteil, while in Spain and Greece the same name is given to a mixture of rye and barley.

In the United States rye is not much used as food except by the German population, and in some of the Eastern States, where it is mixed with corn. The foreign trade in rye is of little importance. The average annual production from 1880 to 1887 was 24,855,300 bushels, worth $15,568,500.

Spring rye is extensively cultivated in the north of Russia, its grain furnishes annually 25,000,000 gallons of alcohol.

In Denmark rye covers four times more territory than wheat. In France it occupies 10 per cent of the surface cultivated in cereals. The richness of a country in cereals is, in general, inversely in proportion to the territory cultivated in rye. In Belgium the area cultivated in rye is nearly equal to the wheat area.

In Austria-Hungary the production of rye is nearly equal to that of wheat. The Hungarian rye is a full grain with a very fine color. In Germany the rye production is double that of wheat.

In Russia the rye crop is three times more than wheat. In 1887 the production was 750,000,000 bushels, of which 51,702,000 bushels were exported as follows:

Distribution exports of rye from Russia in 1887.

	Bushels.
Germany	14,180,276
Holland	10,443,103
United Kingdom	9,204,207
Norway and Sweden	7,838,689
Denmark	2,657,173
Austria-Hungary	1,458,619
Other countries	5,919,933
	51,702,000

(3) Barley.

The annual barley crop of the world is estimated at 865,777,000 bushels, three-fourths of which is grown in Europe. The principal producing countries of the world and the average crop are as follows:

Barley crop of the world.

	Bushels.		*Bushels.*
Russia	129,250,000	Denmark	20,361,000
Germany	92,950,000	Canada	19,770,000
England	92,125,000	Roumania	19,470,000
Austria-Hungary	88,715,000	Bulgaria	15,125,000
Spain	75,450,000	Turkey in Europe	13,750,000
Japan	68,750,000	Netherlands	4,474,000
Algeria	60,225,000	Belgium	3,443,000
United States	58,245,000	Australia	2,887,000
France	49,500,000	Chile	2,750,000
Egypt	27,500,000		
Sweden and Norway	21,037,000		865,777,000

One of the principal uses of barley is for the manufacture of beer. England imports for this purpose 32,450,000 bushels; Germany imports 19,910,700 bushels, and the United States 10,831,000 bushels.

Among the ancient Greeks and Hebrews, and throughout ancient Europe, barley meal was an important food, especially for the poorer classes and for the subsistence of armies. The use of barley bread declined with the introduction of potatoes, and the general cheapening of wheat. In the United States little use is made of barley for food, except a small amount for soups. In the Pacific States it is much used for horse feed.

Barley may be cultivated in a wide range of climates. In general, that grown in warm and dry countries has a fine pale yellow color. Algerian barley is in much demand by French and English brewers. Spain cultivates a black barley specially suited for making porter.

In Spain, Africa, and in Asia, barley is used as a substitute for oats as food for horses and mules. It takes the place of rice and semolina in Germany and Russia. In Japan roasted barley, mixed

with sugar, makes excellent cake. Barley meal is much used in Finland, where it is considered a healthy and nutritious food. The barley of Scandinavia is of very fine quality.

The barley crop of Russia in 1887 was 169,200,000 bushels, and the exports were 34,944,000 bushels sent to the following countries:

Exports of Barley from Russia in 1887.

	Bushels.
United Kingdom	20,031,200
Holland	6,042,200
Germany	3,687,000
Belgium	2,550,000
France	846,600
Other countries	1,787,000
	34,944,000

Barley which has been deprived of its outer shell is called "hulled barley," and when the hulled barley is rounded off and polished off by the millstone it constitutes "pearl barley," which replaces, especially in Germany, rice or semolina in the preparations of soups. In France, in preparing pearl barley, the grain, after being cleaned of foreign substances, is decorticated, or hulled, and separated into two sizes which are worked separately. In Germany and Russia, by the aid of a special apparatus, they cut the grains transversely into three nearly equal pieces, and then put the cut grains into the mill. The mills used for pearling barley have only one stone. This stone, of a special quality, works horizontally or vertically in an envelope of rasped sheet iron, or of metallic cloth. Sometimes the barley is passed through a second mill similar to the first, to make the grains smaller and of higher value.

In the United States barley is an article of importation, not enough being grown to supply the enormous demand of the beer brewers. The average annual harvest in this country for the last eight years is 52,652,462 bushels, worth $31,011,682, and the average annual importation for twenty years is 7,941,532 bushels, at $5,952,951. The production and importation have both increased during the last few years. In 1884, a good year, the crop was 61,203,000 bushels, and the imports in 1888 were 10,831,461 bushels.

(4) Oats.

The annual production of oats in the world is now about 2,300,000,000 bushels, more than one-fourth of which is grown in the United States. Russia also produces about one-fourth the total crop. There are no statistics to indicate the proportion of the total crop used for human food. The average crops of the principal countries of the world, as given in 1885 by M. Tisserand, in the reports of the French Department of Agriculture, were as follows:

Oat crop of the world.

	Hectoliters (2¾ bushels).		Hectoliters (2¾ bushels).
France (1882)	90,798,373	Finland (average)	2,640,000
United Kingdom (1885)	39,390,568	Switzerland (average)	1,872,000
Belgium (1880)	8,840,545	Spain (average)	1,481,000
Holland (1883)	4,030,160	Portugal (included with barley)	
Germany (1883)	94,924,000	Italy (average)	6,711,000
Denmark (average year)	10,521,471	Greece (average)	43,000
Austria-Hungary (1882)	52,282,000	Turkey (average)	1,083,000
Russia in Europe (1880)	196,291,000	Servia (average)	180,000
United States (1884)	176,280,000	Roumania (average)	2,000,000
Canada (1884)	25,624,242	Bulgaria (average)	3,575,000
Sweden (average)	16,688,000	Algeria (average)	574,000
Norway (average)	3,225,000	Australia	3,300,000

In Russia the oat crop in 1887 was 621,000,000 bushels, and the exports were 61,014,000 bushels, sent to the following countries:

Exports of oats from Russia in 1887.

	Bushels.
United Kingdom	30,677,000
Holland	7,552,600
Germany	6,685,700
Belgium	6,494,000
France	6,457,500
Other countries	2,847,200
	61,014,000

The oat crop in the United States has very greatly increased since 1880, while the value has decreased. The statistics for the past ten years are as follows:

Production and value of oats in the United States 1880-1888.

Year.	Production.	Value.	Year.	Production.	Value.
	Bushels.			*Bushels.*	
1880	417,885,380	$150,243,565	1886	624,134,000	$186,137,930
1881	416,481,000	193,198,970	1887	659,618,000	200,699,790
1882	488,250,610	182,978,022	1888	701,735,000	195,424,240
1883	571,302,400	187,040,264	Annual average	565,827,043	181,875,901
1884	583,628,000	161,528,470			
1885	629,409,000	179,631,860			

In 1859 the crop was 172,643,185 bushels; in 1879 it was 407,858,999 bushels, and in 1888 it had increased to 701,735,000 bushels.

Oats, next to wheat, is the principal cereal cultivated in France. The crop of 1882, 89,697,900 hectoliters, was worth nearly $200,-000,000. The average crop in France from 1878 to 1887 was 83,866,365 hectoliters (230,632,503 bushels). In the western provinces of France oatmeal bread was formerly eaten by the poorer classes, but to-day it is necessity alone that will compel them to eat what they term "the black, bitter, heavy, indigestible oatmeal bread." The French

admit that the meal made into porridge is preferable to rice, or even pearl barley.

Yellow oats are generally cultivated in countries where the air is hazy rather than dry, while the black variety is grown where the summers are not very damp. White oats, well known by the iron-gray color of the grain, are cultivated only in countries where the seed may be safely sown in the autumn. The black oats of Canada and of the Cape of Good Hope are of very deep color.

In the United States oatmeal has become a common food among all classes. The enormous increase in its consumption is largely due to the recent improvements in its preparation as "rolled oats," etc.

The best qualities of oats yield about half their weight of meal. The "groats" of Scotland are made by a process of high milling which removes the husk but leaves the grain nearly or quite whole. The groats are then reground, with the stones closer together, to produce the meal, which is of two kinds—a fine meal, used in making the oatmeal cakes or "bannocks," and the coarser meal, used for porridge. Much of the American meal is nearly the same as the Scotch "groats." Some samples of the various brands of the meal put up by English and Scotch millers were shown at the exposition. The milling machinery, however, was not exhibited.

The method of preparing the Scotch oatmeal is described as follows by Mr. Underwood, United States consul at Glasgow:

At the mill oats are put in the kiln, which (in the case used here for illustration) is the upper floor of a chamber, about 18 feet square, having a floor of perforated iron plates. The heat comes from a furnace of anthracite or other smokeless coal, placed about 24 feet below the floor. The heat must be absolutely free from smoke, otherwise the grain will be discolored, and, what is worse, will have a repulsive taste. I could not get the degree of heat as a thermometer is not used. The workmen simply drop a little water upon the floor, and when it "hizzes" in a certain way they know it is hot enough. The ventilation is by an opening in the roof, through which the steam escapes. Oats require a sharp and constantly sustained heat, care being taken to prevent their being burned by overheating. The miller observed that oats need a stronger heat than either wheat or Indian corn.

Oats which have been properly cared for at the farm should not contain impurities to be cooked with them, and should be allowed to lie four hours in the kiln, during which time they must be carefully turned at least three times. A kiln 18 feet square will accommodate 90 imperial bushels of oats at a time. Short oats (*i. e.*, oats with short grains) require less drying, but the long oats produce the sweetest meal. After drying (and a slight parching is thereby understood) the grain is drawn off into a hopper, where it should lie for a day before being put in bags to be ready for the succeeding processes. Two days should elapse between the drying and the beginning of the milling, during which the grain cools slowly. If put into the mill before it is well cooked the meal will not be so sweet.

In milling, the oats pass from a hopper through a machine called a "dickie," containing two sieves, the first of which allows the oats to pass, but retains any foreign substance. The oats pass through the second sieve, where again any dirt or remnant of weeds or stalk adhere to the sieve, and then the oats reach the shelling stones, by which the husks are separated from the grain.

The shelling stones are 4 feet and 8 inches in diameter, and are made of gray stones procured principally from Yorkshire. The under or bed stone, which is stationary, has a surface bristling with points; the upper stone has its under surface of the same character, and moves with great velocity, raised about one-half an inch above the bed. The velocity is so great that it is observed that the oats, in falling through the opening, are all perpendicular, as it were, suspended all endwise. The grain is made to pass twice through the shelling stones to insure thorough separation, after which it falls into another sieve and then into fans, where the husks are blown out. The pure grain is then elevated to a hopper, to be passed through the grinding stones.

In grinding, the object aimed at is to cut or break the grain into small particles, but not to crush it into flour which is unpalatable. Unlike the particles of maize, oatmeal is digestible with a comparatively short cooking.

The best stones are of French "burr," having the surface well honeycombed. They are 4 feet and 6 inches in diameter, and are laid in the same manner as shelling stones. The surfaces (of the points) must be kept sharp and well polished in order to make sure that the grain is well cut, for, if the points of the stone become blunt, the meal will be floury and of inferior quality.

The meal passes from the stones into a box containing three sieves of graduated apertures, the upper, No. 8, the middle, No. 9, and the lower, No. 10, of wire gauze. After passing through these three sieves (to remove any foreign substance still remaining) the meal is ready for consumption. Oatmeal of a recent crop and freshly ground is the best. If not to be immediately used, it should be kept in hermetically sealed cans; otherwise, by absorbing moisture, it will lose its delicate flavor, or become sour and moldy.

(5) CORN.

Corn (Indian corn, maize) is grown as far north as 50° north latitude in Europe and 54° in America, and extends to 40° south latitude. There are three hundred or more varieties, some hard and horny, others tender, varying in color from white to yellow, red, and black, and in height from 18 inches to as many feet. The history of this grain is ably told by Mr. W. H. Brewer in his Report on the Cereal Production of the United States.*

Indian corn is very nutritious and is much used, both in the Old and the New World. Spain, Portugal, Italy, Algeria, Greece, and France cultivate it on large areas, but not much is raised in the north of Europe, and very little in the south of India. America is the country of corn, the United States producing 1,650,000,000 bushels, or three-fourths of the crop raised in the entire world. It was unknown in Europe and in Asia before the discovery of America by the Spanish. The early inhabitants of Peru celebrated the corn harvest in the month of May by grand fêtes.

In Europe Indian corn, or maize, is often called Spanish grain and Turkish grain. In Turkey they know it as Egyptian grain, and in Egypt it is called dourah tourquay.

Indian corn forms the basis of nourishment of the inhabitants of certain portions of America, Africa, Asia, and Europe. One of its

*Tenth Census Reports. Volume on Agriculture.

principal uses in the United States is food for hogs, hence the saying "plenty of corn, plenty of hogs." Large quantities are also used by the distilleries, and by the glucose and starch manufacturers. In France corn is largely used by distillers of alcohol, and it is also fed to horses.

Among the numerous preparations of corn may be mentioned hominy or cracked corn, corn meal, maizena, and cerealine. In these forms great quantities are consumed throughout the United States, but in Europe the people generally are ignorant of the use of the grain except as meal in making corn cakes, or to mix with flour in bread-making. At the time of the famine in Ireland, shiploads of corn were sent there by our generous people, but little use was made of it through ignorance of the best methods of cooking it. Because Americans use corn in immense quantities to feed hogs, Europeans have come to think the grain of little use for human food.

Some "pop corn" exhibited by the United States attracted the curious attention of eminent men on the jury of awards, one of them a leading flour miller of Europe. They had never before seen "pop corn" and were totally ignorant of its common use in America. Accompanying the "Wild West Show" in Paris were some pop-corn peddlers, whose wares were looked upon by the Parisians with as much curiosity as Americans might bestow upon Chinese peddlers of dried cuttlefish.

The canned-corn industry has developed to immense proportions in the United States, and the average quantity put up each year is now 3,000,000 cases of 24 boxes each, or 72,000,000 cans, the harvest of 40,000 acres.

In Guatemala they soak the corn over night in water containing a little lime. They then boil it and pound it into a paste from which they make corn cakes. Sometimes they add the fecule of banana or yucca.

In South America corn meal or flour, under the name of maizena, is used to make a drink called *chica.* In Hungary and Italy they slightly soak the corn and dry it over the fire on sheets of iron, making what they call corn granules.

In Biscay they make a delicious corn bread that they call *borrona.* Persia cultivates corn but does not export it, and the same may be said of China and Japan. The corn of South America and Central America is of good quality.

Australia cultivates the white, the yellow, and the red corn. The average annual crop in the United States from 1880 to 1888 was 1,657,948,726 bushels, valued at $676,833,874.

The following table shows the corn crop for a series of years and also the foreign trade:

Quantity of corn produced, and of corn and corn meal imported, exported, and retained for consumption in the United States, from 1867 *to* 1888, *inclusive.*

Calendar year.	Production.	Year ending June 30—	Imports.	Total production and imports.	Exports, domestic and foreign.	Retained for home consumption.	Consumption per capita.	Percentage exported.
	Bushels.		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bush.*	
1867......	768,320,000	1868	50,270	768,370,270	12,495,786	755,874,484	20.44	1.63
1868......	906,527,000	1869	90,833	906,617,833	,288,685	898,329,148	23.79	.91
1869	874,320,000	1870	89,538	874,409,528	2,140,487	872,269,041	22.62	.24
1870......	1,094,255,000	1871	111,344	1,094,366,344	10,673,553	1,083,692,791	27.39	.98
1871	991,898,000	1872	58,568	991,956,568	35,727,010	956,229,558	23.56	3.60
1872... ..	1,092,719,000	1873	61.536	1,092.780,536	40,154,374	1,052,626,162	25.26	3.67
1873	932,274,000	1874	76,003	932,350,003	35,985,834	896,364,169	20.95	3.86
1874......	850,148,500	1875	38,098	850,186,598	30,025,036	820,161,562	18.66	3.53
1875......	1,321,069,000	1876	51,796	1,321,120,796	50,910,532	1,270,210,264	28.14	3.85
1876......	1,283,827,000	1877	30,902	1,283,857,902	72,652,611	1,211,205,291	20.13	5,66
1877......	1,342,558,000	1878	13,423	1,342,571,423	87,192,110	1,255,379,313	26.38	6.49
1878......	1,388,218,750	1879	33,869	1,388,252,619	87,884,892	1,300,367,227	26.61	6.33
1879......	1,547,901,790	1880	58,876	1,547,960,666	99,572,329	1,448,388,337	28.88	6.49
1880......	1,717,434,543	1881	75,155	1,717,509,698	93,648,147	1,623,861,551	31,55	5.45
1881......	1,194,916,000	1882	69,621	1,194,985,621	44,340,683	1,150,644,938	21.79	3.71
1882	1,617,025,100	1883	25,989	1,617,051,089	41,655,653	1,575,395,436	29.09	2.57
1883......	1,551,066,895	1884	4,894	1,551,071,789	45,247,510	1,505,824,279	27.11	2.92
1884......	1,795,528,000	1885	4,507	1,795,532,939	52,876,456	1,742,656,485	30.52	2.95
1885......	1,936,176,000	1886	16,104	1,936,192,104	64,829,617	1,871,362,487	32.04	3.34
1886......	1,665,441,000	1887	30,536	1,665,471,536	41,368,584	1,624,102,952	27.12	2.48
1887......	1,456,161,000	1888	37,493	1,456,198,493	25,320,869	1,430,877,624	23.25	1.74
1888......	1,987,790,000							

Among other important corn producing countries are the following:

	Hectoliters (2¾ bushels).		Hectolitres (2¾ bushels).
France	9,967,000	Italy	31,334,000
Austria-Hungary	35,282,000	Roumania	25,000,000
Bulgaria	8,557,000	Germany (Alsace)	165,000
Spain	13,173,000	Australia	2,000,000
Portugal	7,800,000	Egypt	1,843,000
Russia, except Poland	6,788,000	India	10,000,000
Turkey in Europe	4,230,000	Uruguay	500,000
Servia	1,800,000	Argentine Republic	60,000,000
Greece	982,000		

(6) BUCKWHEAT.

Buckwheat or black wheat, grows in temperate climates. There are three principal varieties, ordinary, silvery buckwheat grown in Holland, Sweden, Russia, etc. and Siberian buckwheat, which is more hardy but less nutritious than the other varieties.

It is an important food in some parts of France, especially in Brittany. The average annual crop from 1878 to 1887 was 27,814,000

bushels. In Russia the crop in 1886 was 80,400,000 bushels, and in 1888 it had decreased to 60,000,000 bushels.

In the United States buckwheat is the least important of the cereal products. About two-thirds of the crop is grown in New York and Pennsylvania. The average annual crop from 1880 to 1888 was 11,155,880 bushels, worth $7,178,107.

(7) MILLET AND SORGHUM.

Millet and sorghum are largely cultivated in the warm countries of Asia and Africa. They are also raised in Spain, in central France, and in Switzerland and Germany, but their culture is not generally favored, because of the poor condition in which they leave the soil.

Millet is ordinarily sold in Russia under the form of white meal. This meal is of as much importance to the Russians as buckwheat. It is of little importance in the agricultural industry of France. The total harvest is about 900,000 bushels. It is much cultivated in Austria-Hungary while in Holland, Belgium, Italy, and Portugal, it is grown on limited areas. It is also grown in Africa, Java, China, Japan, and other oriental countries. The principal varieties are *Paniceum miliaceum*, *Setaria italica*, and *Pervicellaria spicata*.

The common sorghum (*Sorghum vulgare*) is not a food plant. Two species, the *sorghum doura* and *sorghum alepense*, are much cultivated in Africa, Persia, and Hindoostan. The *bechna* of the Arabs is *sorghum cernum*. Greece cultivates several varieties of *doura*. In Africa, as in Asia and in Spain, they make hasty puddings, pancakes, and bread of *doura* flour. The Africans make the beer called *boza* or *bouza* from a mixture of *doura* and barley. Sorghum is extensively grown in Algeria and in Senegal, it is utilized for the fine alcohol distilled from it. Black sorghum is grown in Guadeloupe. In the United States, it is cultivated for the sirup and sugar prepared from it, as mentioned under class 72 of this report. In Italy, its cultivation has been developed. Millet and sorghum are hulled the same as barley, and the flour made from them, either pure or mixed with wheat flour, makes a bread which is very good when warm, but which blackens and hardens when cool, and easily crumbles.

(8) RICE.

"The greatest part of the population of the globe," says Tisserand, "live on rice." It is of more importance for human food than both wheat and rye. Asia is the greatest producer of this grain and it is estimated that the 750,000,000 Asiatic people consume not less than 275 pounds of rice per head each year, a total of 206,250,000,000 pounds or 100,000,000 tons. Europe receives each year from Asia 1,980,000,000 pounds of rice.

In Europe the rice cultivation is limited. Italy raises the largest proportion, or 1,562,000,000 pounds, and the rest of Europe, 178,200,000 pounds. It is not grown in France, although many attempts have been made to introduce it there. Some is grown in the district of Valencia in Spain, and in Portugal and Greece, and Turkey in Europe and Egypt cultivate it. Rice was grown in ancient Babylon and Syria. In the year 1084 it was introduced into Java, and in 1694 into the United States. The Moors first grew it in Spain. Some time in the sixteenth century Italy began to cultivate it.

In the United States in 1850 the rice crop, grown chiefly in South Carolina, was 214,739,318 pounds, but in 1880 it was only 122,010,715 pounds, the decrease being due largely to competition with foreign rice, the importation of which in 1888 was 142,354,001 pounds, either crude or as granulated rice or rice meal.

Rice grows wild in some parts of Paraguay, though little attention is given to its cultivation, and about $30,000 worth is imported.

Rice is cultivated in the republic of Colombia, yet nearly all that is consumed in the seaboard towns is imported for the reason that there are not enough hulling machines in the country to supply the demand. The ordinary method of preparing rice is very primitive. When the rice is dry enough for use, it is stripped from the branches by hand, and the husks beaten off by the common wooden mortar and pestle. This operation is very imperfect, for it breaks the grain and does not completely remove the husk. Rice grows abundantly in all the provinces of Brazil. It is in the wild state in many of the regions of the interior, and is the chief nourishment of many tribes of Indians. There are two known species one that grows along the river banks which are frequently inundated, and another that grows on dry lands. The river species is far the better. Brazilian rice is of superior quality, but notwithstanding the fact that it is so largely cultivated, the machines are not at hand for its proper preparation for food and considerable quantities are imported.

In Spain, in the province of Valencia, there are 70,000 acres under rice cultivation and the average annual crop is 221,000,000 pounds, yielding 160,000,000 pounds of rice free from the husk. In quality it is pronounced to be fully equal to the Carolina rice of the United States.

There are numerous establishments in Belgium for the preparation of rice. The East Indies are the chief source of supply. The imports in 1888 were 88,969,480 kilograms, and the exports 26,934,045 kilograms.

Holland also is largely engaged in rice milling, the raw product coming chiefly from Java. Italy has some large rice factories for the preparation of the native production, and much in addition that is imported.

The rice of Algeria, of Spain, and of Southern Russia is of fine appearance. Rice from Egypt is generally unsightly because it is not well prepared. Hundreds of varieties of rice from Oriental countries were shown at the Exposition. They may all be grouped into two principal classes—the upland, dry or mountain, and the aquatic rice, grown near the sea level. The India rice, used in making curry, is an example of the upland class. The South Carolina variety may be taken as the best example of the lowland or sea-level rice, and it is also perhaps the best quality of rice in the world.

In Japan there are two hundred and seventy varieties of rice which are divided into early, middle, and late rice. The glutinous rice that the Japanese extensively cultivate, and which they call *mochi-gome*, serves to make *hoseii*, and the cake called *mochii.* Its flour is used to make the cake called *kanzaraschi.* This rice in China, known as *ngomi*, is used in making rice wine. Ordinary rice, especially the variety called *okato*. is used by the Japanese in making *sake* and vinegar.

To prepare rice for food, the paddy or rough rice is put in the husking mill to remove the yellow coating and to separate the inner white grain, and it is then winnowed and sifted into several grades of chaff, rice flour, broken grains, middlings and smaller grains, and prime. For European markets, the rice is generally glazed by shaking the grains in a large drum lined with sheepskin. The broken rice is ground into flour of several grades of fineness.

The rice fields of Ceylon cover 700,000 acres, and the harvest, though great, is not sufficient for the home demand, more than $8,000,000 worth being annually imported. There are very many varieties grown in Ceylon, samples of which were exhibited in husk and decorticated.

The culture of rice is very highly developed in British India, especially in the provinces of Bombay and Madras. The plant is very productive in seasons of sufficient rain. From 1865 to 1875 there was exported 5,340,000,000 kilograms of rice.

Rice is one of the principal food products of Cochin China, the annual harvest being about 540,000,000 kilograms, and the exports about 350,000,000 kilograms. There are four large establishments for the decortication and bleaching of rice for exportation.

(9) Teff, eleusine, bamboo, etc.

In Abyssinia and Egypt the grains of the teff (*Poa abyssina,* are made into a good white flour, samples of which were shown at the Exposition.

In the exhibits from India, Japan, and other Oriental countries, there were samples of several minor grains of more or less importance for food.

The seeds of *Eleusine coracana* furnish a farinaceous food for the working classes of India, Ceylon, and China. The seeds also of *Oplismenus frumentaceus* serve as food in China and Japan.

Bamboo grains from *Bambusa arundinacea* were exhibited as food. In India it is called bamboo rice. The grains from Senegal were long, small, and horny, or nearly translucent.

In China and Japan the seeds of *Coix lacryma* are used in making soup. Paspale, the grains of *Paspalum frumentuceum*, or *latifolium*, is used in India and some other countries for making barley.

The white quinoa (*Chenopodium quinoa*) grown in South America, Mexico, and Oceanica, and cultivated in France, furnishes small, round grains which are good substitutes for semolina in the preparation of soups.

IV.—FARINACEOUS PRODUCTS AND DERIVATIVES.

(1) SEMOLINA.

Semolina is the hard, central portion of wheat which is not ground to powder in the ordinary process of milling. The best quality is obtained from the hard wheats of Algeria, Spain, Italy, and some parts of Russia. It was formerly made by grinding moist wheat, but the product would not keep more than 20 to 25 days. By grinding dry wheat between stones that are rougher than those used for flour milling, the semolina produced will keep for a long time. Marseilles has long been well known for the excellent quality of semolina made there. The wheat is worked only when it is dry. After being perfectly cleaned, and moistened with about 1 quart of water to 100 pounds of grain, it is submitted to the action of some quick-running mill stones which remove the husks and crack the grains. When cooled, the wheat is bolted and gives semolinas of various sizes, which are cleaned in rectangular sifters slightly inclined, and in circular mechanical sieves. As worked at Marseilles, the wheat yields 50 per cent semolina, 35 per cent flour, and 15 per cent of bran. The semoule is called the best part of the grain. It contains more gluten than is in the flour. The paste that it forms with water increases much in volume.

The smaller sizes of semolina are used in the manufacture of macaroni and other alimentary pastes. The larger sizes are used for soups.

The annual exportation from Marseilles is about 5,000,000 pounds.

(2) ALIMENTARY PASTES.

The manufacture of macaroni, vermicelli, and other alimentary pastes is an important industry in many countries. The exhibit of these foods by Italy, France, Russia, China, Japan, the Argen-

tine Republic, and other nations, was very complete, leaving little to desire, either in quality or in variety of forms. Lyons is extensively engaged in this industry, producing annually upwards of 20,000,000 pounds, valued at more than $2,500,000.

The quality of macaroni and other pastes depends much on the kind of wheat employed in their manufacture. Semolina made from the hard wheat of Algeria is in France considered very superior. The tender wheats yield fine meal and flour, but do not produce good semolina.

The macaroni and vermicelli industry originated in Italy where this food forms one of the principal nourishments of the people. For a long time the Italians had the monoply of the business, and the products were exported throughout the world. Alimentary pastes are largely prepared in Belgium, the annual production aggregating upwards of 1,750,000 kilograms, nearly all of which is consumed in the country. There is, in addition, nearly an equal amount imported annually.

The method of making macaroni in France is as follows: The paste prepared from semolina, which has absorbed from 25 to 30 per cent of water, is well kneaded and put into a bronze or copper cylinder, with the bottom pierced with holes or fitted with a brass gauge plate. The sides of the cylinder are double, the space between being filled with steam or hot water. When the piston descends in the cylinder, under the action of a powerful hydraulic press, the paste comes through the holes in the bottom in the form of tubes that are quickly cooled by a ventilator. These tubes are cut in lengths of 30 to 40 inches and carried to the drying room, where they are spread upon screens until thoroughly dried and ready for packing.

(3) STARCHES: ARROWROOT, TAPIOCA, ETC.

Starch is the term applied to the fecula or amylaceous matter found in the fruits, roots, or cellular tissue of most plants. The size, structure, and form of the grains vary greatly in different plants, and may readily be distinguished. The commercial starches include arrowroot, tapioca, sago, corn starch, potato starch, rice starch, wheat starch, plantain starch, buckwheat starch, greenheart starch, and horse-chestnut starch.

Arrowroot is the starch of several kinds of tropical plants, of which the most important is *Maranta arundinacea* and *Maranta indica*. The principal commercial kinds of arrowroot are Bermuda, St. Vincent, East India, and Natal. To prepare the arrowroot the rhizomes of the plant are washed and reduced to pulp which is strained through sieves of progressive fineness and allowed to settle. It is then passed through a fine sieve into clean water, settled, and the brown layer removed from the surface. After being again strained and settled it is placed on cloths to harden, broken up fine on trays, and dried in the sun and wind.

Arrowroot is also made from several spieces of *Canna, Tacca,* and *Zamia.* Tapioca, cassava, and manioc, and tapioca and manioc flour, are made from the rhizomes of the manioc or yuca (*Jatropha manihot* or *Manihot utilissima*), a plant very common in many intertropical and temperate regions. It is extensively grown in South America, Central America, Jamaica, India, and Oceanica. In Brazil more than thirty varieties are cultivated, and the flour prepared from it replaces bread for the great majority of the people, especially in the interior districts.

In Guatemala, Salvador, and Peru the manioc is called *yuca,* and in the Argentine Republic it is known as *mandioca.* The juice of the *Manihot utilissima* is bitter and contains a poison which is removed in the process of preparing the food product. The *Manihot aipi,* a species closely related to the bitter cassava, but having a sweet, wholesome root, quite free from poisonous juice, of a reddish color. The root is cooked and eaten as a vegetable. Some of the cassava or mandioca meal is obtained from this plant, although the greater part comes from the bitter cassava.

The manioc or yuca is much cultivated in Paraguay. The flour forms for the natives their indispensable basis of food and replaces the potato of Europe. They make bread and delicious cake of this flour. In preparing the manioc flour the roots are peeled, washed, and rasped, and the pulp is left to itself for four or five days in water. It is then put in bags and pressed, and the liquid drained into a vat, when the starch settles to the bottom. This starch is washed two or three times and dried in the sun, or by other means, and then crushed and sifted. Any traces of poison are lost by exposure to the air. The flour or meal thus made is used in the preparation of cassava cakes.

To transform the starch or flour into commercial tapioca, it is soaked in water and sifted out by means of a large colander on metallic plates heated to 200°. The starch in drying is transformed into the hard, opaque, irregularly shaped grains known as tapioca. The drying or baking is often done in earthen ovens instead of using hot plates.

In British Guiana the juice is extracted from the grated root by means of a long cylindrical basket-like squeezer, woven from palm. One end of the filled bag is attached to a beam and a weight suspended at the lower end, and the bag in lengthening presses the juice from the pulp.

Sago.—Sago is the starchy matter extracted from the pith of several kinds of palms, of which the most important are *metroxylon sagu* and *metroxylon rumplii,* the former abundaut in Sumatra, Java, Borneo, and some other eastern islands and countries.

Borneo is the headquarters for sago culture, the territory of Saravak alone furnishing more than half the sago of the world. About 20,000 tons are annually exported. The commercial sago is made

from the meal by mixing the meal into a paste with water, and rubbing it through sieves to granulate it. The spherical forms are made by allowing the sago as it drops from the sieves to fall into a shallow iron pot held over a fire.

Rice starch.—Rice contains more starch than any other cereal, ranging from 75 to 85 per cent. Simply steeping and crushing does not separate the starch, and resort is had to caustic alkaline lyes.

Potato starch.—Potato starch is obtained by cleaning and grating the potato, soaking in water, and straining to separate the tissues. It is then bleached by sulphuric acid or chlorine, again washed, strained, and dried.

Potato starch is known also as British or English arrowroot. It is the cheapest starch in commerce, and is largely used for laundry purposes as well as for food.

Artificial tapioca and sago are extensively made in France from potato starch, and serve their purpose well, serving as an agreeable and cheap substitute for the expensive imported products.

The establishment of N. & J. Bloch, at Tomblaine, near Nance, exhibited some fine specimens of potato and other starches, and various farinaceous preparations made from peas, beans, corn, etc., as also some artificial tapioca and sago made from potato starch, pronounced by experts equal in nutriment to the genuine article.

Corn starch.—Indian corn contains about 53 per cent of starch, which is extracted by soaking the grain in water for 24 to 30 hours, grinding to a paste, and washing in cylinder sieves as in the preparation of potato starch. The best grades of cornstarch are used as a substitute for arrowroot.

Some large starch factories are located in New York and in Cincinnati, and it is also made in large quantities in France, Hungary, Australia, and Brazil, and other corn-producing countries.

Chestnut starch.—Horse-chestnut starch is largely made in southern France. Water containing carbonate of soda is used to remove the bitter taste.

Bebeeru starch.—In British Guiana starch is made from the seeds of the green heart, or bebeeru tree (*Nectandra*).

Plantain meal.—Guiana arrowroot, or plantain meal, is the starch extracted from the unripe fruit pulp of plantains (*Musa paradisiaca*).

Banana meal.—Banana meal is obtained from the fruit of the banana (*Musa paradisiaca*) by drying and pulverizing the fruit before it is ripe. It is produced in considerable quantity in Brazil and Central America.

Buckwheat starch.—In England some buckwheat starch is made.

(4) Dextrine and glucose.

The manufacture of dextrine and glucose are important industries in France and in the United States. Among the best exhibits of these products were those shown by the establishment of N. & J.

Bloch, already referred to. Gluten is separated out in the process of making starch from wheat and other grains. It is a valuable food product.

Glucose is prepared from potato or corn starch which is soaked in warm water until the grains are swollen, when sulphuric acid is added which transforms the starch into dextrine, then into glucose under the action of the diluted acid heated to 100 C. The acid is then neutralized by chalk. After resting for about three hours the substance is filtered through animal charcoal and partially evaporated, and the sirup is sold to brewers, confectioners, and others. Further mention of this industry will be found in the chapters on Class 72.

V.—FLOUR MILLING.

(1) IMPORTANCE OF THE INDUSTRY.

There are no general statistics to show the actual production of the flour mills of the world. In the United States there are between 25,000 and 30,000 millers, and the average annual yield of the mills is about 75,000,000 barrels. Minneapolis is the great milling center of the Northwest. The enormous mills there established consumed in a recent year 24,000,000 bushels of wheat, from which was made 5,450,163 barrels of flour. The full capacity of the mills is said to be 35,000,000 bushels a year. The great increase of the milling industry in the Northwest, where spring wheat is chiefly grown, is mainly due to the important invention of the middlings purifier, about 1860, by a Frenchman named Perigault. In 1871 the purifier machine was introduced in the Minneapolis mills, and many improvements have since been made. Spring wheat, which was formerly much less in value than winter wheat, now brings a higher price than the latter.

The annual production of the flour mills of France is 73,000,000 barrels, of which 1,230,000 are exported and the rest made into bread.

Great Britain imports annually an enormous quantity of wheat meal and flour. The figures for 1887 and 1888 are as follows:

Imports of wheat meal and flour into the United Kingdom in 1887 *and* 1888.

Wheat meal and flour.	1887.	1888.
	Cwt.	*Cwt.*
Germany	588,876	1,109,179
France	97,620	10,864
Austrian Territories	1,390,605	1,946,038
United States	14,873,443	12,557,096
British North America	958,873	785,163
Other countries	147,128	413,433
Total	18,056,545	16,912,773

The value of the above imports in 1887 was $50 100,000 and in 1888 $47,684,000.

An exhibit worthy of special merit was that of the Société Anonyme des Grands Moulins de Corbeil. This is the largest milling establishment, not only in France, but in Europe, the mills being located at Corbeil and at Havre, and in 1889 the actual work was 900,000 pounds of grain per day. At the Havre mills American and Hungarian wheat are worked, and at the Corbeil mills, wheats from Australia and other countries. The exhibits included all varieties of flour and the various derivatives, and to show the quality of the flour, bread was made from it each day at a bakery in the Exposition grounds. I am much indebted to Mons. A. Lainey, the able director of this establishment, and who was my associate on the international jury, for many courtesies and kind assistance in the preparation of my report on cereals.

(2) Principal methods of milling.

In the French, English, Belgian, and Swiss sections of the Exposition there were good displays of the improved machines now in general use in the preparation of "process" or "patent" flour.

The exhibits of Thos. Robinson & Son, of England; Millot, of Zurich, and Hignette, of Paris, were especially complete.

In the United States section there were only four or five machines to show the many improvements incident to the history of the milling industry in our country during the past ten or fifteen years. It was very encouraging to Americans, however, to see in the foreign sections many machines made from American models, and to find in the catalogues of foreign manufacturers so much praise of the American machines made by them.

The gradual reduction system of milling was invented in Austria or Hungary, and the attention of America was seriously called to it only within the last twenty years, especially at the Philadelphia exhibition of 1876, yet so many improvements have been made in our country that we may almost say that the system as now operated is an American rather than a foreign one.

The object to be accomplished in milling wheat is (1) to free the grain from the coverings of woody fiber; (2) to remove the oily "germ" near the lower end of the grain, and (3) to reduce the central portion of the wheat to flour.

The outer envelopes are light, nearly colorless, and form 3 per cent of the weight of the grain. They are very fragile and spongy, and are of no more use as food than so much straw. The testa or episperm contains two coloring matters, one an orange yellow and the other pale yellow. In proportion as one or the other color predominates the grain is more or less old. The testa adheres quite closely to the parts it touches and contains a little gluten. The tissues

with the germ are the parts most injurious to the preparation of good flour, affecting the color and the texture. The embrynal membrane is uncolored, and is composed of cells inclosing some flour of quality inferior in color, but charged with gluten. The endosperm is composed of large cells, in which the granules of starch are found. Near the center the cells are softest. They contain less starch and more gluten as they approach the outer portion of the endosperm. In milling it is almost impossible to entirely separate the flour attaching to the embrynal membrane.

The germs are prepared in England in a special manner for children's food.

THE OLD AND THE NEW METHODS OF MILLING.

By the old method of milling it was thought sufficient to grind the grain at once to powder and to separate the bran by sieves or bolts of cloth. Many supposed that by retaining the bran there was additional nourishment in the flour, but the followers of Alexander Graham, of Connecticut, who so strongly advocated the use of such flour, are fast losing their faith in the Graham bread.

A great improvement on the old milling is the process known as high milling. By this method the millstones are placed far enough apart to break rather than crush the wheat, and the fragments are then separated into flour, middlings, and bran. The "middlings" or coarse fragments of the center of the grain, are then thoroughly cleaned and ground into the pure "patent" flour. This cleaning or purifying of the middlings is the vital part of the process, and very many machines have been devised to accomplish the work.

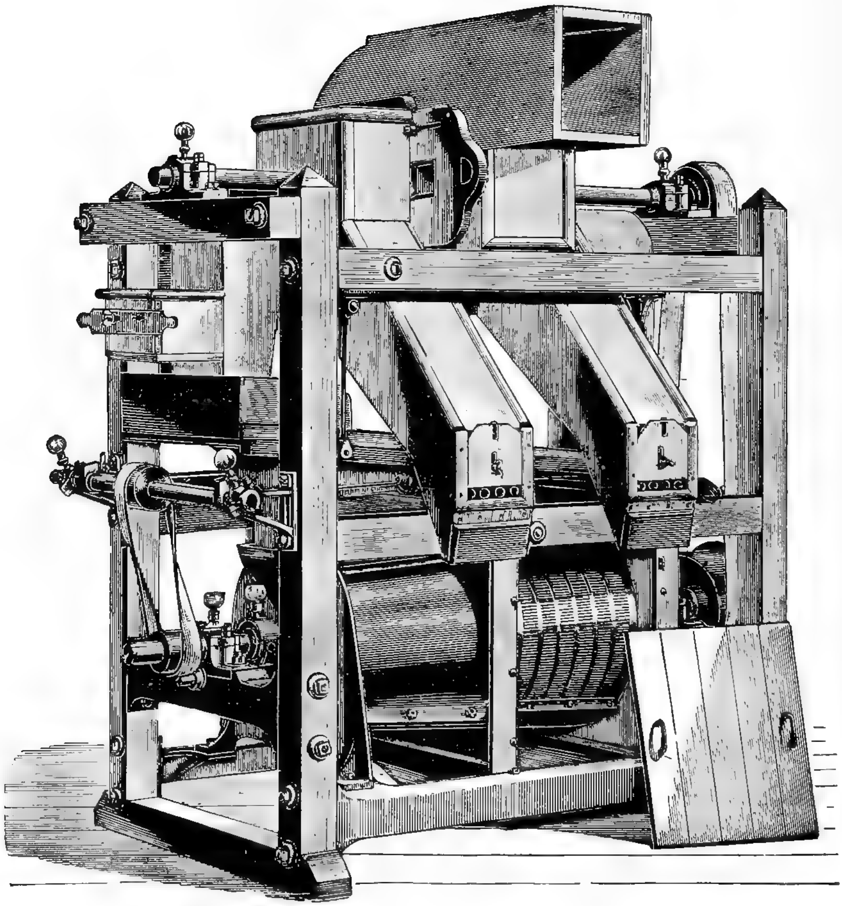
By the gradual reduction process the grinding is done by rollers, the grain passing through successive sets of rollers, each set adjusted nearer together than the preceding, and between each grinding the fragments of the grain are separated into flour, bran, and middlings. The purified middlings from the last reduction rollers are ground between stones or rollers, and yield the finest grade of flour.

(3) PRESERVATION OF GRAIN.

To the miller the proper preservation of the grain before it is ground is often a difficult problem, for it is constantly subject to injury from fungous growths, from insects, and from fermentation.

The ancient Romans preserved their grain in great subterranean vaults or silos, free from moisture, a means still employed in many countries. There are some of these vaults or silos in Spain, in which may be stored sufficient grain to feed 150,000 men for a year. Grain has been found in ancient Egyptian granaries perfectly preserved after a lapse of thirty centuries or more.

It seems unnecessary here to discuss the hundreds of improved granaries devised in past years. I will mention only one which I



COMBINED ASPIRATOR AND SEPARATOR.

saw in operation at the great military bakehouse in Paris. It is the vertical system invented by Huart, by means of which the grain is kept in motion and is thoroughly ventilated in its passage through several chambers, and from one floor to another of the storehouse. An effective check to the growth of fungoids, or of insects upon or in the grain, is a temperature sufficiently high or low to destroy the eggs.

(4) GRAIN-CLEANING MACHINES.

A very important preliminary work of the miller is to separate the grain from all impurities, and to clean the surface of the berry itself. There are numerous machines adapted to the removal of cockle, smut, oats, chips, pieces of metal, etc. Most of these machines consist of screens to separate heavy matters, and an air blast to remove light impurities. The screens are made with openings, shaped like the impurities to be removed. Magnetic separators are sometimes employed to remove metallic substances.

The cleaning of the surface of the grain is done by friction, or by brushes. One form of scourer "consists of vertical rods revolving about the axis of a cylindrical steel jacket, and operates by the resultant attrition of the berries among themselves, and against the rods and the surface of the cylinder."

In order to better remove the dirt adhering to the surface in the crease of the grain, the berry is split through the crease by grinding between stones or rolls set just far enough apart to split the grain but not to crush it to flour.

The general principles involved in the separators are separation by (*a*) size, (*b*) weight, (*c*) difference of form, (*d*) friction to clean the surface, (*e*) difference of specific gravity, (*f*) magnetism in passing the grain over a plate strongly magnetized to remove pieces of metal.

Mechanics have endeavored to combine several of the above principles in a single machine, and some progress has been made towards this end.

Plate I represents a machine in which are combined several of the principles involved in proper cleaning of wheat. In the upper portion, the grain is subjected to an air blast to remove the dust and light impurities, and it passes through or over a sieve which extracts all the pieces of straw, stones, large grains, and all substances larger than the wheat berry. From the sieves the wheat falls into the cleaner which removes adherent dirt by the friction of the grains against themselves in a cylinder, one-half of which is of solid cast iron with a grooved surface, and the other half of steel plate pierced with oblong holes permitting the dust and barbs of wheat to escape into a receptacle below. When the wheat comes from the cleaner, it is once more subjected to a strong air blast.

Another machine was exhibited in the English section which was the same as the preceding, with the addition that inside the cylinder a drum turned at high speed on which some brushes are so arranged as to brush the surface of the wheat.

In the washing machine shown in Fig. 1 the wheat enters by the feeder A into the funnel B whence it goes to the center of the basin B 1, and falls on an adjustable cap C which is adjusted by the wheel C 1. The water which is raised from the reservoir EE runs between the cap C and the inclined plate D, meeting in its course the falling wheat and washing it; G is a turning arm, on which the propellors G 1 are fixed, by means of which the wheat may be led in I

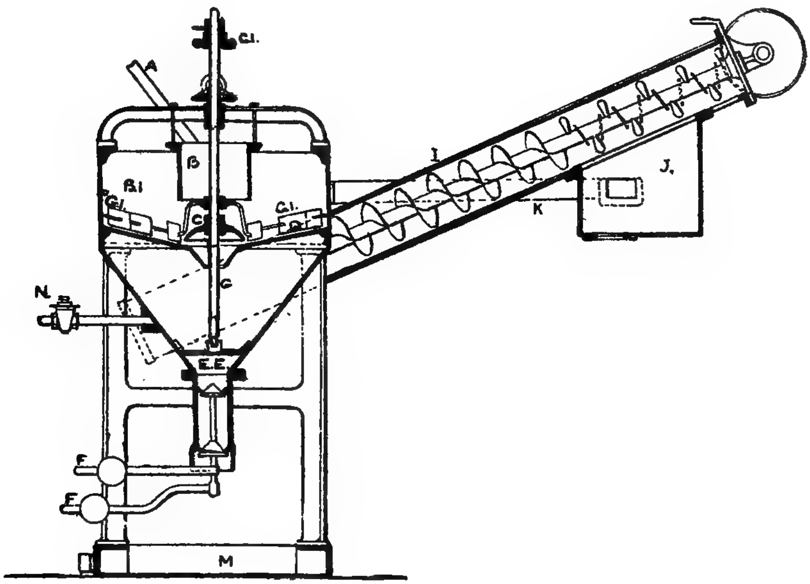
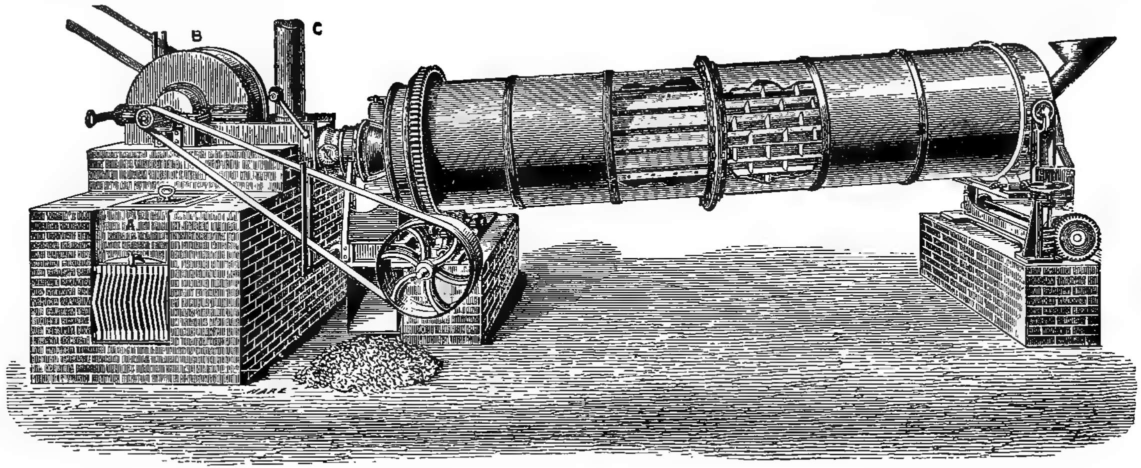


FIG. 1.—Grain Washer.

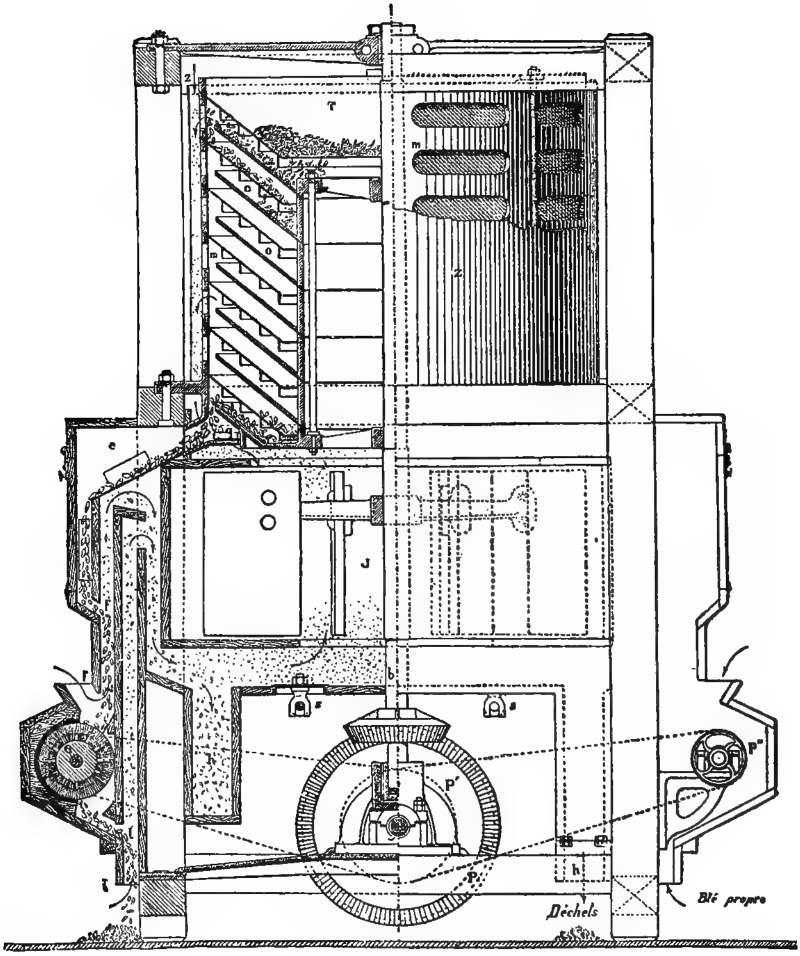
in the direction desired; J is a reservoir to receive the water that the serpentine draws out and which is returned to the machine by the tube K; FF are hard levers, opened one after the other, to remove the rubble that is washed from the grain and falls into the reservoir.

A grain dryer made on the Gibbs' system was shown by Thos. Robinson & Co. and is illustrated in Plate II.

A. Goubet, of Louvain, Belgium, exhibited a machine to remove particles of stone and to wash and dry the wheat. It is cylindrical form and the grain is subjected to a jet of water which cleanses the surface. Light impurities rise to the surface, while heavy ones sink to the bottom, and the cleaned grains pass into the large cylinder to be dried.



GRAIN DRYER, GIBBS' SYSTEM.



HIGNETTE'S GRAIN CLEANER AND POLISHER.

The grain-brushing machine, of which a sectional view is given in Fig. 2, was exhibited by Brault, Tisset & Gillet. The direction traversed by the wheat and the position of the brushes are shown in the illustration.

Among the many interesting machines exhibited by J. Hignette, of Paris, was a new invention of grain cleaner for removing the hair or fuzz from the upper end and the germ from the lower end and also for polishing the surface of the grain. (Pl. III.) The apparatus is

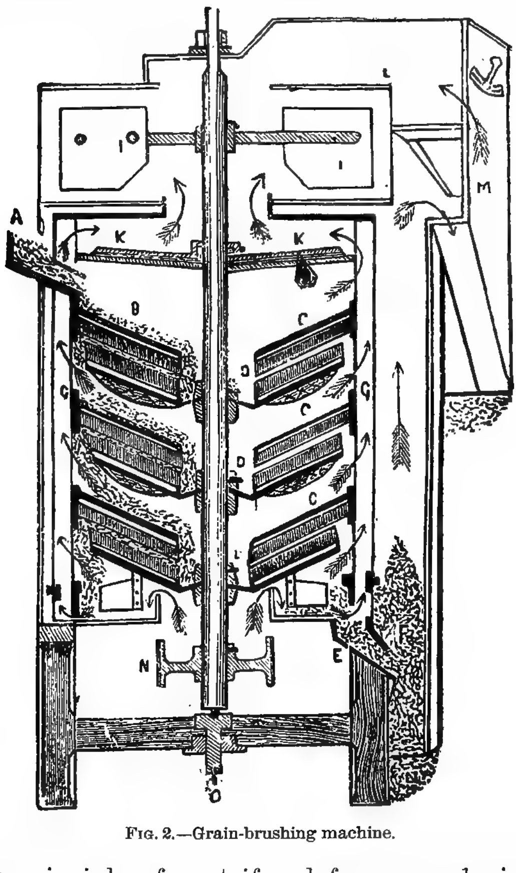


FIG. 2.—Grain-brushing machine.

based on the principle of centrifugal force, employing two series of cones, one series fixed and the other series movable. The fixed cones are held between iron bands, superposed, which form an exterior column or cylinder. Between these fixed cones are inserted the movable cones, which are also held by iron bands superposed and forming an inner cylinder, and are revolved by a vertical shaft. The movable cones have at their upper edge a free space between them and the circumference of the exterior cylinder, while the fixed cones at their lower edge end at a few centimeters from the cylinder in motion. There is thus communication at the top and

bottom between all the compartments formed between the two cylinders. The movable cones are lined with emery on their upper side to present a rough surface to the jagged under side of the fixed cones. In its passage through the cones the grain is cleaned and the fuzz is worn from the upper end. To degerm the wheat the last movable cone at the bottom is replaced by a rough emery stone, which grinds away the lower end of the grain to release the germ. From the cones the wheat falls into a compartment, where it is polished by revolving brushes, which rub it against an emery surface, removing all adhering particles, which are then drawn away by an air suction.

The machine of which the internal arrangement is shown in Plate IV was exhibited by A. Millot, of Zurich. The grains fed in the hopper fall upon a sieve with four sizes of perforations; the first separates

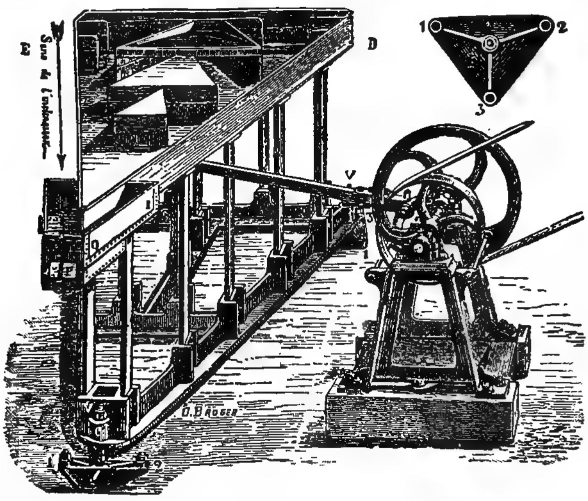
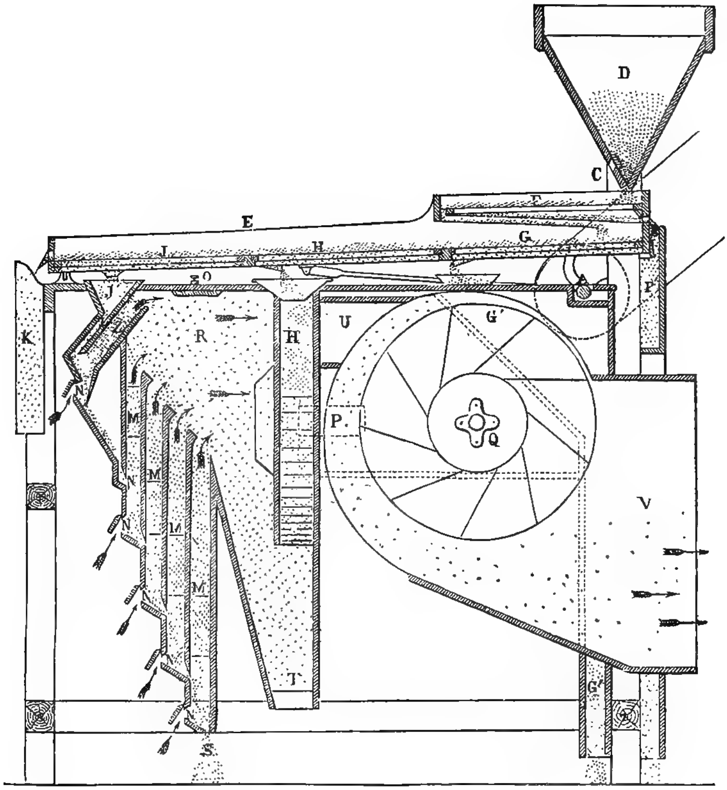


FIG. 3.—Stone separator.

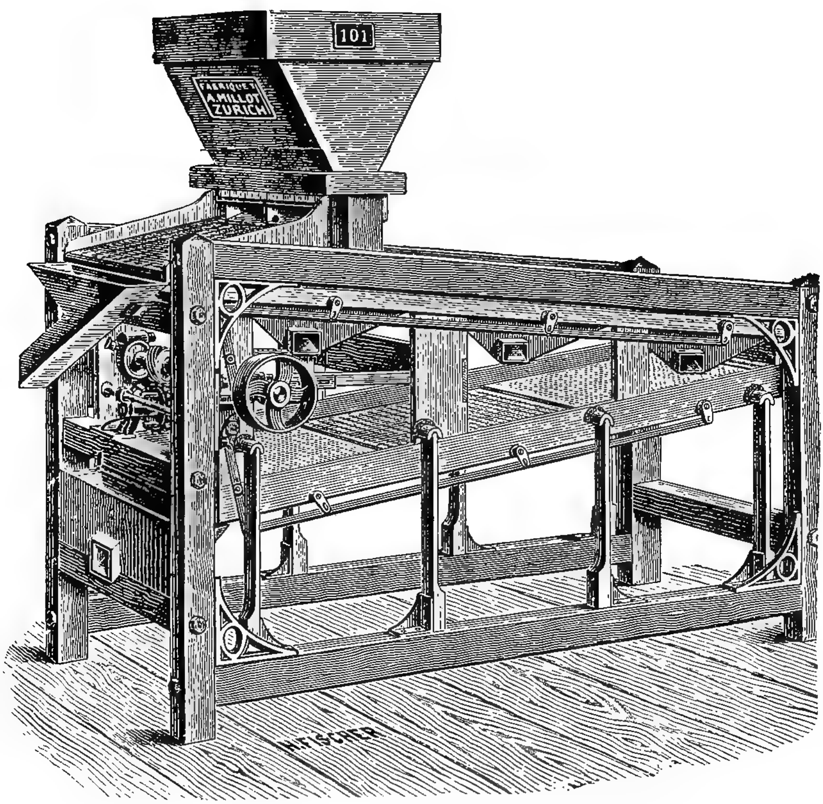
out the particles of dirt ; the second refuses grains of large size ; the third rye and small grains, and the fourth the best grains. The latter fall upon a slanting sieve where they are subjected to an air current which separates the lighter grains and the heavier ; better ones fall successively into four vertical compartments, and are further cleaned by subjection to currents of air, as shown by the arrows Millet showed also a sorting machine (Pl. V).

The stone separating machine, Fig. 3, was exhibited by French and Swiss manufacturers. It extracts all stones heavier than the grain, whatever their form or size.

The wheat-cleaning machine exhibited by Les Gendres de Lhuillier, of Dijon, illustrated in Fig. 4 and Plates VI–VII, performs most of the work necessary to a complete cleaning of the grains of wheat preparatory to grinding. It has a sieve, with aspirator; a sortre, to

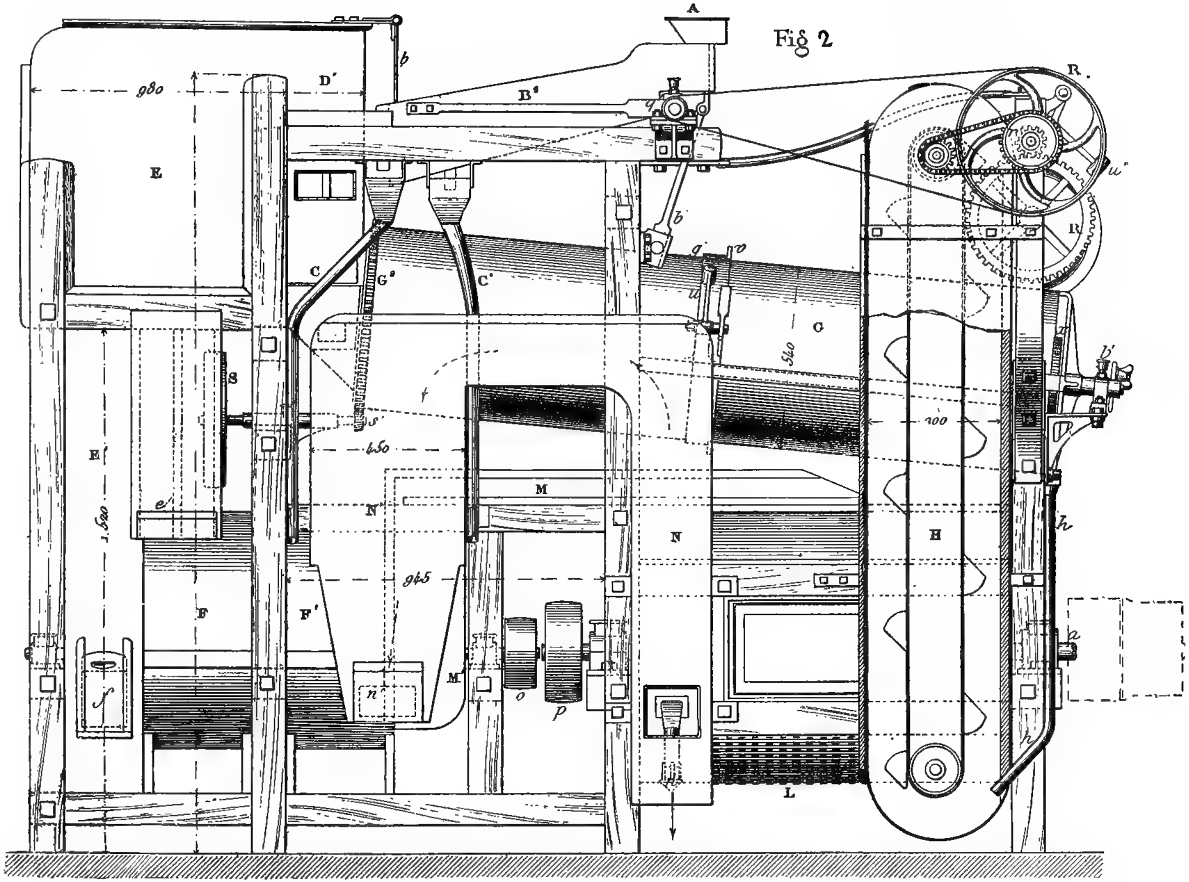


MILLOT'S SEPARATOR-ASPIRATOR.



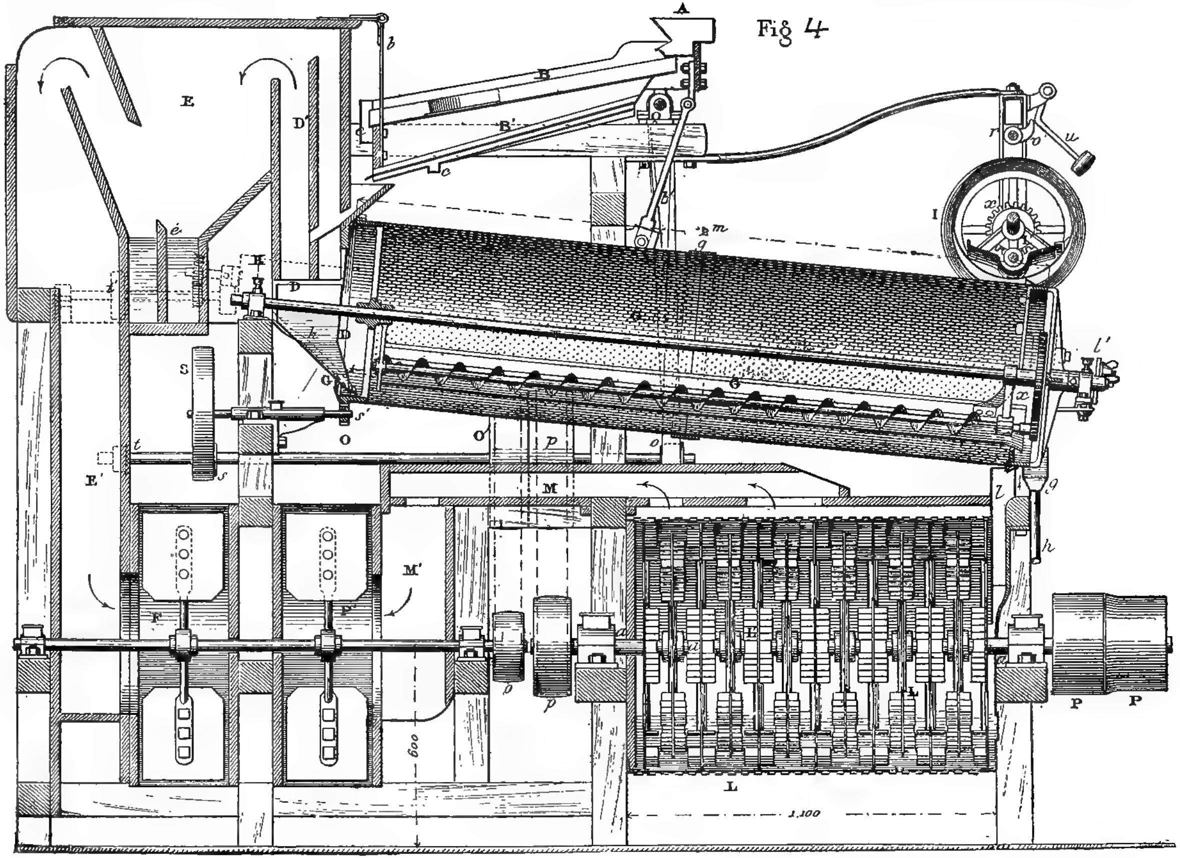
GRAIN-SORTING MACHINE.

Fig 2



LHUILLIER'S WHEAT-CLEANING MACHINE, PLAN.

Fig 4



LHUILLIER'S WHEAT-CLEANING MACHINE.

separate the berries according to size, and a depointer, which removes the fuzz at the end of the berry and by a current of air cleans the loose dirt from the crease. The illustrations show in detail the construction of the machine. Fig. 4 is a general view; Plate VI represents the entire machine in front elevation, a part of the cup chain cut; Pl. VII is a longitudinal cut through the center.

The wheat is fed into the hopper A Pl. VI, which distributes it over the first sieve B, which separates out the stones or other large impurities. The grain passes through the sieve and falls on a second fine sieve, which retains the wheat, but passes foreign substances smaller than the wheat. From the sieve the wheat berries fall into a hopper D, leading to the sorter, and meeting in their course a current of air F in the chamber E. The sorter is the ordinary rotating cylinder, the interior surface provided with cells or dents to receive the grains. In the depointer the grains are subjected to the action of a series of revolving paddles L, which precipitate the berries

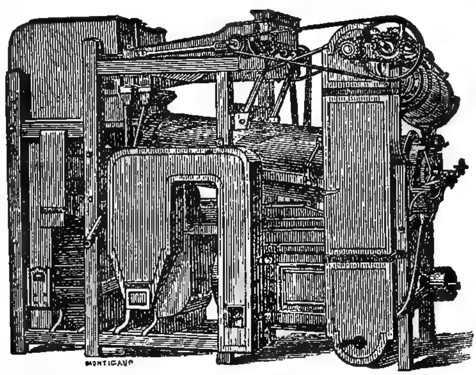


FIG. 4.—Lhuillier Wheat-Cleaning Machine, general view.

against the rough surface of the cylinder, thus removing the fuzz on the end of the grain, and by the action of aspirators F and F 1 the adhering dust is also removed. The wheat cleansed by this machine is afterwards freed from metallic impurities by passage through the magnetic separator.

The American "Eureka" grain-cleaning machines were shown in the Belgian section, and were also exhibited by the American manufacturer, S. Howes, of Silver Creek, N. Y., who was awarded a gold medal. The "Eureka" machines are used throughout the world. It may not be improper, therefore, to give the following recommendations of the manufacturer concerning the system:

A line of machinery may embrace more or less in number of machines, but under ordinary circumstances the following will make up an excellent and, in our judgment, necessary outfit:

One receiving separator, to rid the wheat of coarse material, sticks, grain headings and other large trash invariably found in wheat as it comes from the farmer's hands.

One milling separator, to rid the grain of small trash, oats, chess, straws, etc., and render it fit for treatment by the scouring and smutting machine.

One smutter, upright or horizontal, to remove adhering impurities from the berry. Many millers deem it advantageous to employ two smutters or scourers, and we very strongly recommend the practice, as we believe results invariably justify the slight additional cost.

One brush machine, upright or horizontal, to polish the wheat after scouring, and to eliminate any particles of dust that may adhere thereto.

One milling separator. Although not absolutely essential, we strongly recommend the employment of this machine in this location, or step, in the cleaning process. A considerable amount of screenings, chess, loosened bran, etc., the effect of which, in the reduction of the wheat, is to blacken or discolor the flour product, will be removed, and to just that extent will the operation of the bolts be facilitated. We should, perhaps, state right here a fact well known to a very large number of millers, viz: No matter how thoroughly cleaned wheat may be, or how perfectly fitted for reduction, its continued handling, before reduction, will always result in detaching a little more of the adhering or incorporated impurities. It is for this reason that we recommend the employment of the second milling separator.

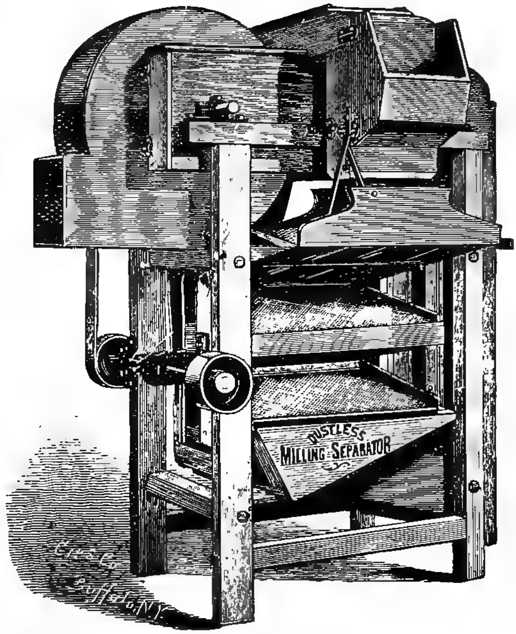
One magnetic separator, to remove particles of iron, wire, broken nails, screws, etc. (that may have thus far followed on with the wheat), and prevent their passing on to the reducing mechanism, which they are very liable to materially injure, or, escaping these, pass into the bolts or purifiers, when serious injury to the cloths will almost inevitably result.

The "Eureka" receiving separator, with scalper and separator, to be used for cleaning wheat, barley, oats, and other grain is shown in Plate VIII, Fig. 2. It is entirely dustless, as the first separator is placed before the screen, thereby causing the fan to absorb the dust. There is also a scalper and second separator. The scalper throws off sticks, straws, headings, etc., before grain goes to the main screen. The large, wide, separating leg receives the grain after it has been screened and removes a large amount of chess, smut, and light, shrunken grain.

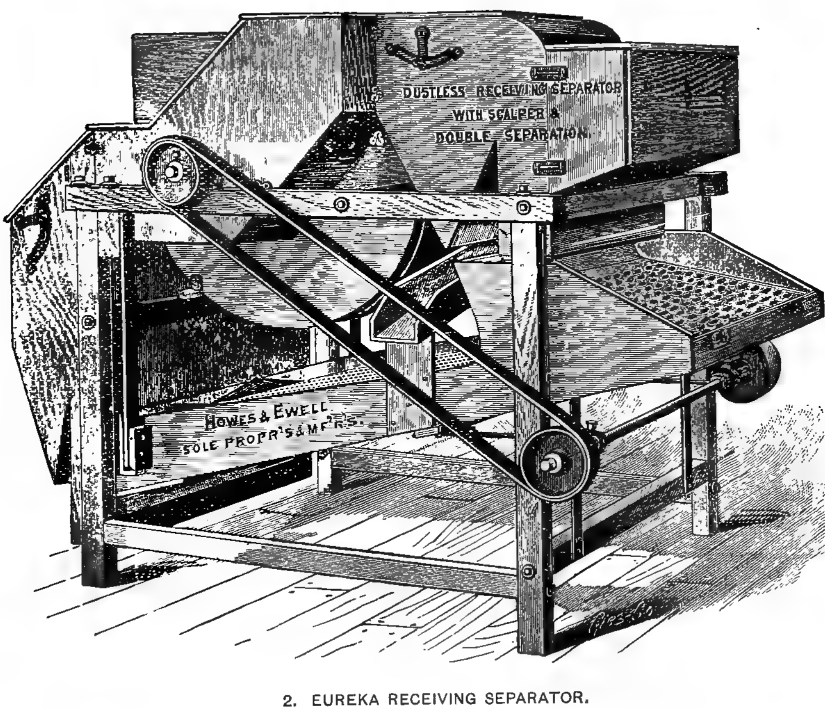
The "Eureka" separator shown in Plate VIII, Fig. 1 has in the upper portion an air blast to remove dust and light impurities, and the grain then falls on an oscillating screen and distributer which rejects straw, pieces of wood, and like substances, and scatters the wheat evenly over a series of sieves which separates the oats, barley, and other foreign bodies, easy to remove with sieves. The wheat is next freed from tares and small grains, and finally passes into the sorter to separate it into various sizes.

The "Eureka" milling separator shown in Plate IX is arranged with screens of three sizes, superposed. The first two retain impurities larger than the grain, and the third size retains the good grain and allows the smaller seeds to pass through. A strong air blast acts upon the material to carry off the dust and light impurities.

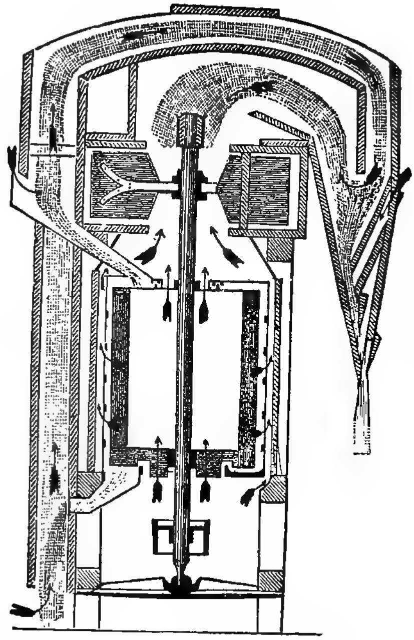
Some horizontal machines of similar construction were also exhibited.



1. S. HOWE'S "EUREKA" SEPARATOR.



2. EUREKA RECEIVING SEPARATOR.



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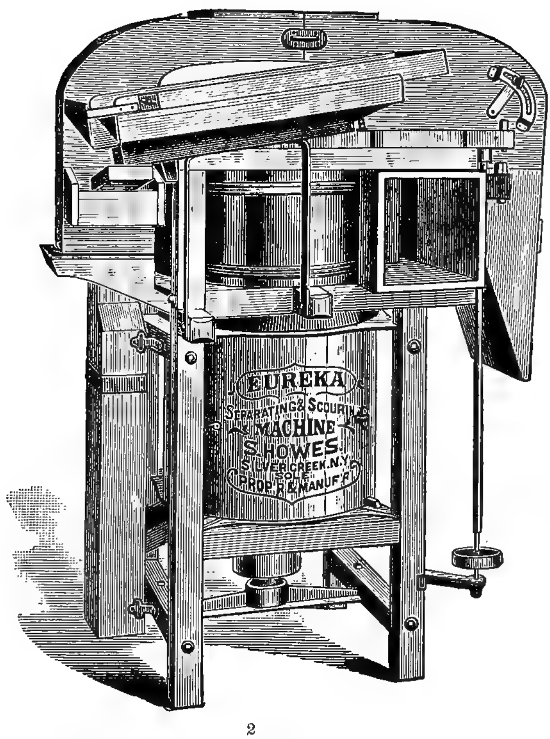

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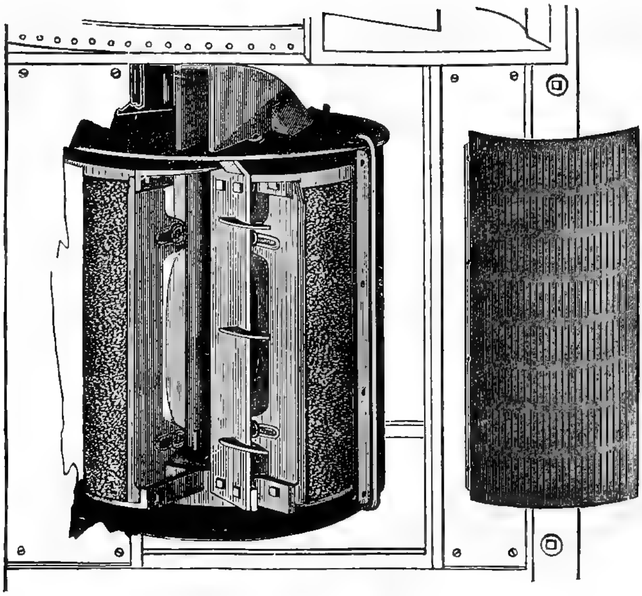
"EUREKA" GRAIN SMELTER AND SEPARATOR.



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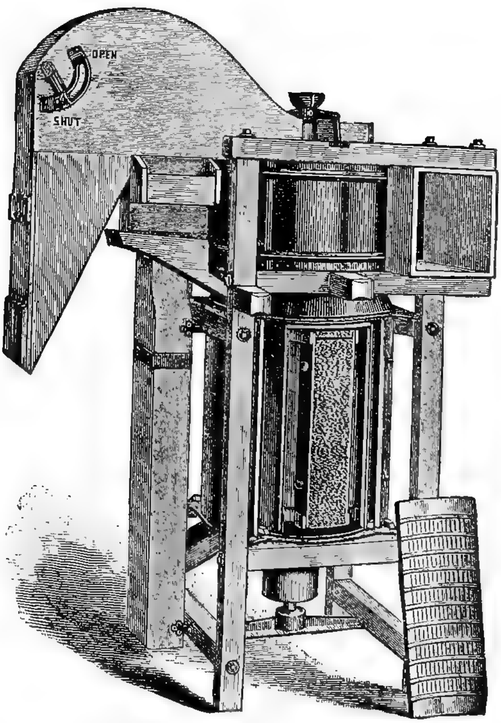


2

S. HOWE'S "EUREKA" BRUSH MACHINE.

The "Eureka" brush machine is intended to be used in connection with the separator, having for its special object the removal of impurities adhering to the surface of the grain. The brushes revolve inside a cylinder and may be adjusted to suit the size of grain worked. A horizontal machine of similar construction was also exhibited. The brush of the machine is shown in Plate x, Fig. 5.

The "Eureka" magnetic separator, Fig. 5, is very generally employed by millers to remove metallic substances from the grain.

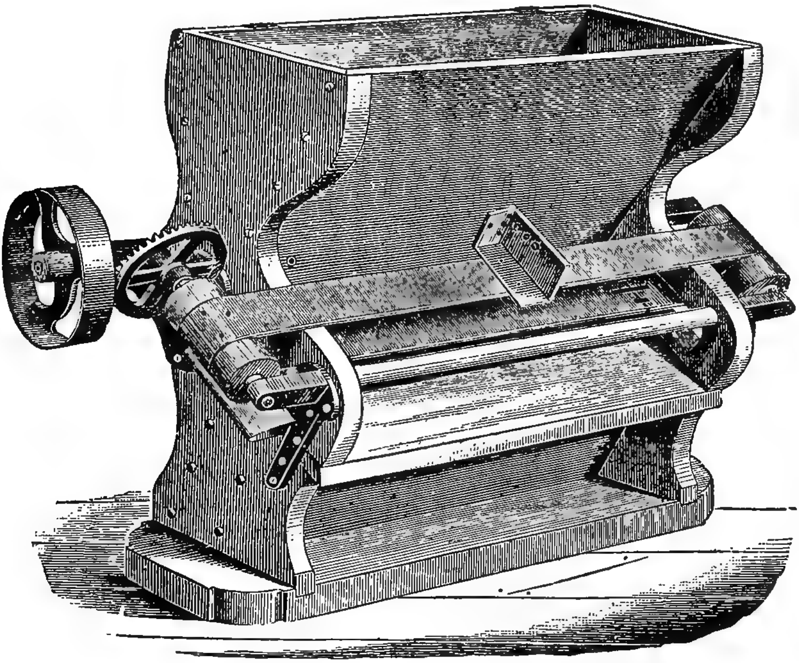


FIG. 5.—"Eureka" magnetic separator.

These machines are from 30 to 65 inches long, 17 inches wide, and 26 inches high, having a capacity of 30 to 300 bushels an hour.

(5) THE GRADUAL REDUCTION SYSTEM.

There was a very complete exhibition of milling by gradual reduction in the interesting display of Thomas Robinson & Son, of Rochdale, England. The entire process was shown in operation daily in a model mill on the Quai d'Orsay. The grand prize awarded to this establishment was well deserved. The steps in the process, as exhibited by Robinson, are briefly as follows :

The wheat having first been cleaned, it is passed through the grading machine which separates it into two sizes ; the large grains are sent to one side of the first break or set of rollers, and the smaller grains to the other side where the rolls are set closer together. The

first break simply splits the wheat through the crease, and the wheat then passes to a scalper and rescalper which liberates the crease dirt. The tailings of the scalper then pass to the second break, in which the rolls are placed somewhat closer than in the first break. The product then passes over a scalper which liberates the flour and middlings made by it. The tailings from this second scalper pass to the third break mill, which is fitted with still finer fluted rolls placed still closer together. This further reduces the wheat; the product, as before, passing to a scalper.

This process is continued until the wheat has passed through five different break rolls and five scalpers. The product which remains is then sent to a bran roll, which is fitted with very finely corrugated rolls. It is then scalped, and the tailings of the scalper go to a bran duster and pass off to a bran sack. The product of the five scalpers consists of middlings, coarse semolina, and a small quantity of flour. It is all put in a reel to take out the flour, and the middlings are separated from the semolina. The middlings go to a sieve purifier, and after they are thoroughly purified, they are ground between smooth rolls which reduces them to first patent flour. The coarse semolina, or germy middlings, go to a gravity purifier which separates them into four sizes, and each size is then submitted to a suitable air current which separates and carries away all light particles of fluff. They then go to the sizing rolls which break them down into fine middlings, and at the same time flatten out the germ which then passes to a clothed reel, or centrifugal, which dusts the flour out, and by means of a coarse sheet, or cut-off, allows the middlings to drop out of the germ which passes off to a sieve and is finished. The middlings are then thoroughly purified on a sieve purifier, after which they are reduced by smooth rolls and made the second patent flour. The tailings of the purifiers and the product of the bran scalpers are taken to a centrifugal, which sizes them into coarse or fine tails. They then pass to the tailings rolls which nearly clean them, and they are thoroughly finished in the low grade rolls.

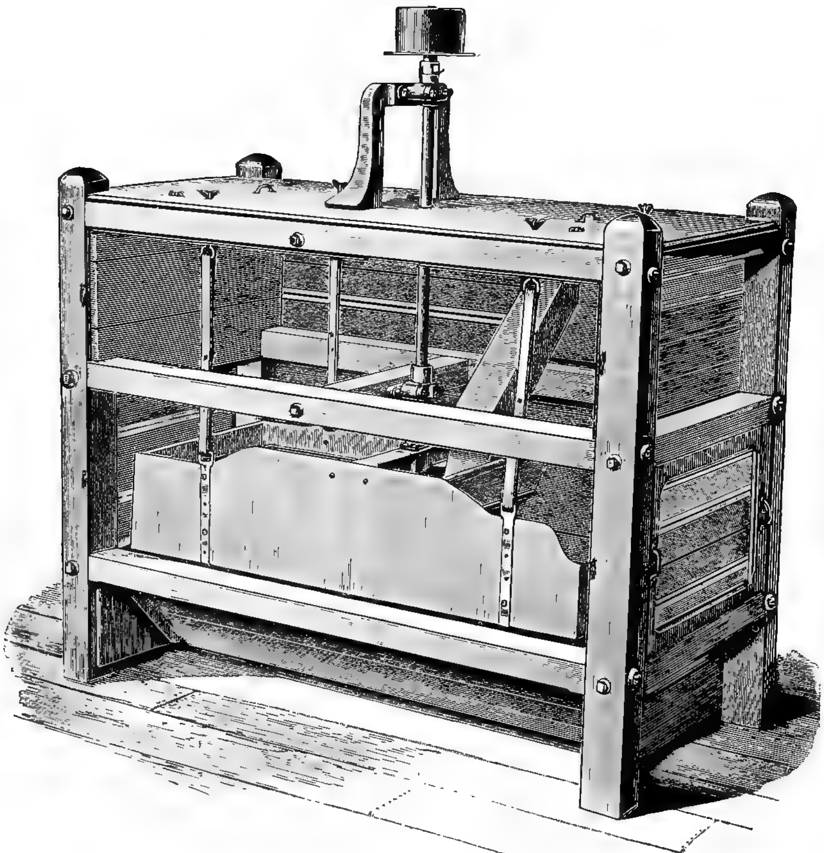
The above operations are automatic, the products passing by spouts, or elevators, from one machine to the next.

(6) Scalpers, Middlings Purifiers, Bolting Machines.

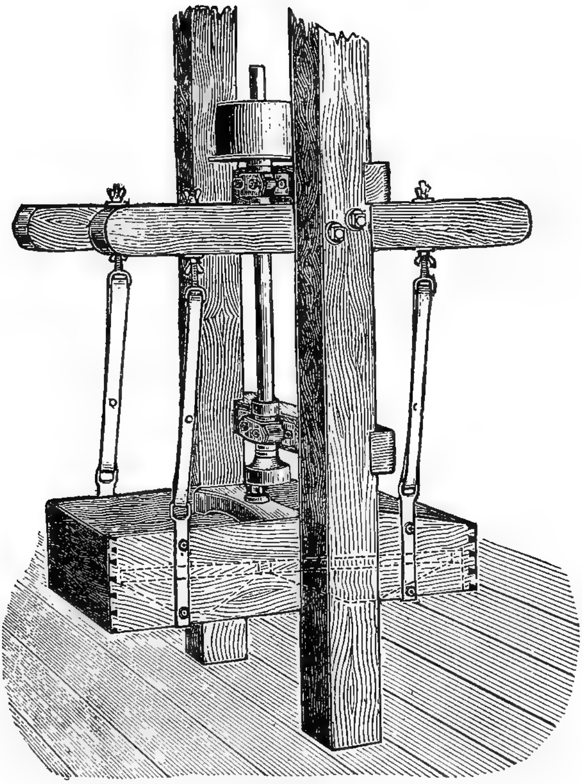
The scalping dickey shown in the Robinson model mill (Plate XI) makes three distinct separations, viz: broken wheat, semolina, and break flour.

The method of scalping with a reel is said to be objectionable because some of the best semolina is made into break flour by the rough action of the reel. The scalping dickey has a very gentle motion and reduces the quantity of break flour about one-eighth.

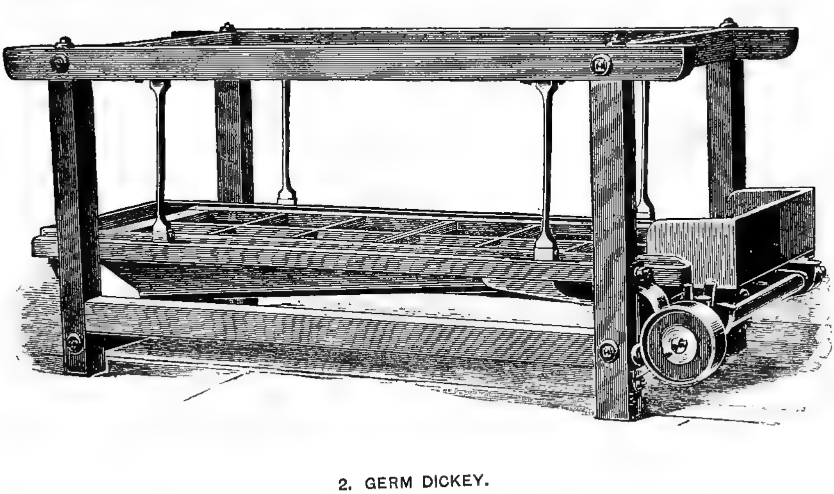
The wheat-grading machine used by Robinson & Son (Pl. XII, Fig. 1) consists of a rotary sieve suitably clothed. It is from 3½ to



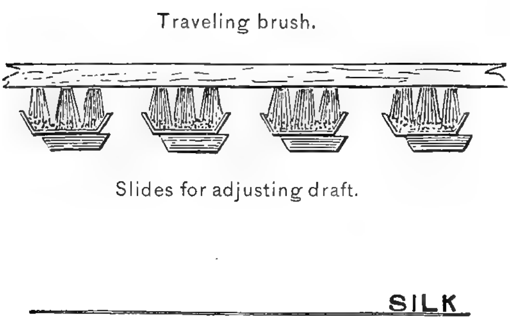
ROTARY SCALPING DICKEY.



1. WHEAT GRADER.



2. GERM DICKEY.



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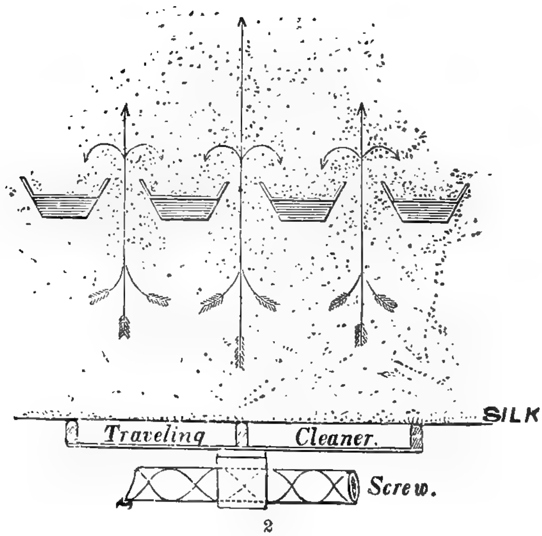


2

MIDDLINGS PURIFIER.

5 feet in length, 6 feet high, and $2\frac{1}{2}$ to $3\frac{3}{4}$ feet in width, of capacity from 20 to 85 bushels.

The germ dicky (Pl. XII. Fig. 2) is intended to liberate impurities, especially germ, also to keep the stock as pure as possible down to the last reduction, and to make a perfect separation between flour and offals.

THE MIDDLINGS PURIFIER.

The middlings purifier, patented by Robinson, is made on the sieve principle, and it is claimed that an intermediate product is separated which is not obtained by other machines.

The action of the machine is described as follows by the manufacturers:

Above the silks are placed a number of V-shaped troughs (see Pl. XIII, Figs. 1–2) which are fixed so close together that the upward current of air is greatly intensified when passing between their narrow spaces, and a comparatively light draft will carry with it even the heaviest impurities, but after passing between the troughs the air expands, and, losing some of its strength, can only carry up the very lightest impurities to the stive room; the heavier particles then fall down into the troughs. Thus a new product is obtained, which formerly either fell back on to the silk, or was partly carried away into the stive room and partly deposited on corners or chambers so inconvenient to clean out.

The troughs are automatically cleaned by means of a traveling brush, which sweeps the impurities into a worm at the tail end of the machine, whence they are spouted away as desired.

The exhaust chamber over the sieves is divided into separate compartments, which are so arranged that the draft can be accurately adjusted to suit the different sizes of middlings in the various stages of purification.

It is fitted with our patent automatic vibrating feed, which delivers the middlings in a perfectly even strain across the whole width of sieve.

The silks can be changed in five minutes, and are most effectively cleaned by means of a traveling cleaner, which also serves to support the silk and prevents any possibility of the middlings accumulating in one place.

The middlings can be cut off at any required point by means of the double interchangeable worm underneath and a divisional hopper board.

A purifier working on the principle of gravity was also exhibited by Robinson, which could be adapted for purifying large semolina or germ middlings. The material is fed upon a shaking sieve or grader, clothed with four different sizes of silk; each number of silk delivers its semolina into a separate compartment, where it falls upon a series of adjustable slanting boards, and by means of the exhaust fan four distinct separations are made in each of the four compartments, as follows: (1) The light fluff, germy, and branny particles which are taken away to the store room; (2) the heavier branny and germy particles which fall into the tailings spout; (3) the lighter and germy semolina which is separated from (4) the sharp purified semolina.

The George T. Smith Middlings Purifier Company, of Jackson, Mich., was awarded a gold medal for its exhibit of centrifugal flour-dressing machines, middlings purifiers, and dust-collectors.

The style of middlings purifier exhibited by the Smith Company (Pl. XIV, Fig. 1) is extensively used in America and Europe. It is described as follows by the manufacturers:

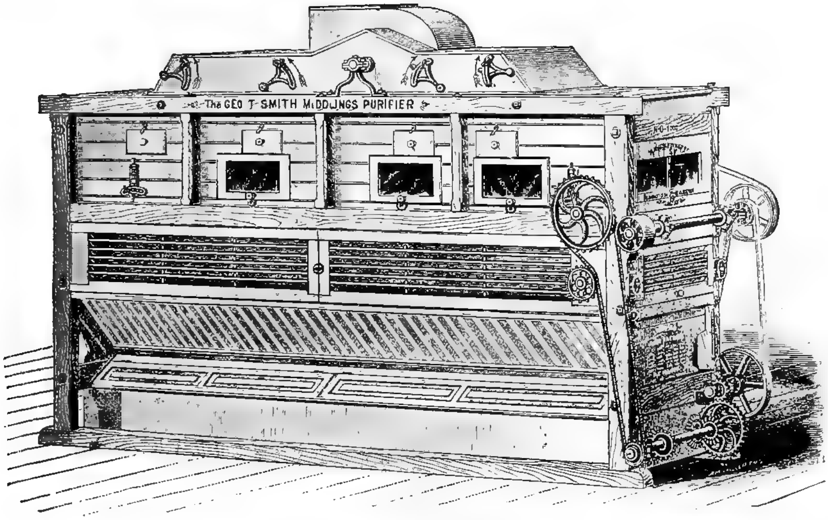
The George T. Smith Middlings Purifier as originally constructed contained the following elements which were never before combined in any machine for the same purpose, or in the same relation to each other, viz: An upward air current through the covering of a reciprocating sieve clothed with silk of increasingly coarser mesh from head to tail; an inclosed air space above the sieve, divided by transverse partitions into separate compartments having practically no communication with each other, and each opening into the chamber of an exhaust fan through an adjustable valve arranged to regulate the strength of the air current through each compartment separately; a series of dust-settling chambers or testing pockets corresponding in number to the compartments above mentioned, and a brush device operated automatically and working against the under side of the sieve clothing. The principles of purification which this organization was adapted to carry out have never been departed from in the manufacture of this machine. Only such modifications have been made in its construction as were calculated to increase the efficiency and convenience of their application.

It is well understood that the continuous air currents upwards through the sieve of a middlings purifier cause the very fine particles of flour and dust to adhere to the threads of the silk, and that granules of middlings too large to pass through become wedged in the meshes on the upper side of the silk, thus closing up the openings to such an extent as to materially lessen its sifting capacity. As soon as this closing-up process commences, waste and bad work result: the first from material which should have been sifted through the cloth being thrown over the tail of the sieve, and the last from the impeded and uneven flow of the air currents. Hence it becomes a matter of the very greatest importance that the meshes of the cloth should be kept free and open.

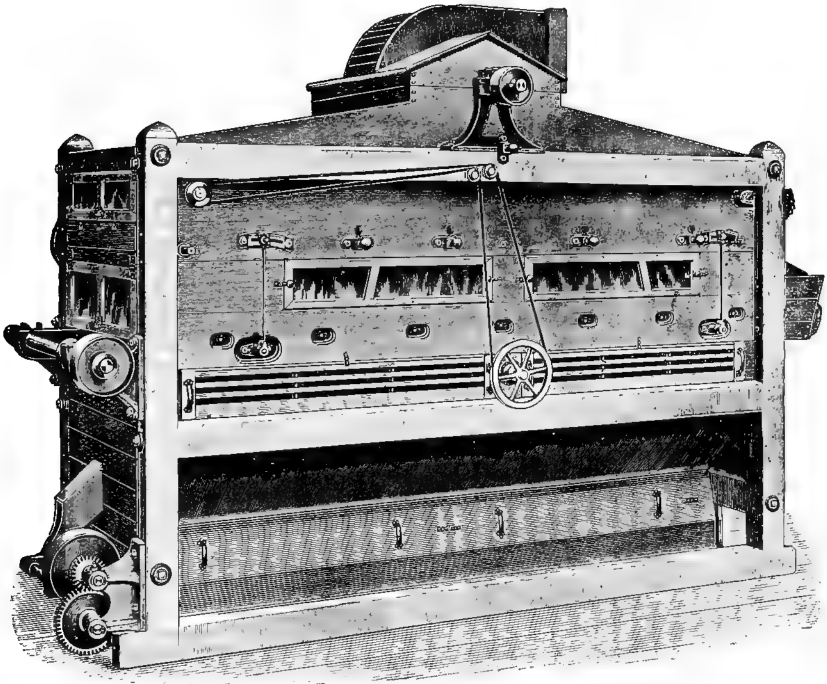
Numberless devices—of which knockers, whippers, air blasts, and brushes working on top of the cloth, in endless variety of construction and application, are only a few samples—have been employed for this purpose, but none of them have acceptably accomplished the end for which they were designed.

The traveling brush sweeping the under side of the silk will keep its meshes constantly free and open, will not in any degree interfere with the necessary even flow of the middlings passing over its upper surface, can not from its position force any impurities into the purified middlings, and is the only device which does or can answer these requirements satisfactorily.

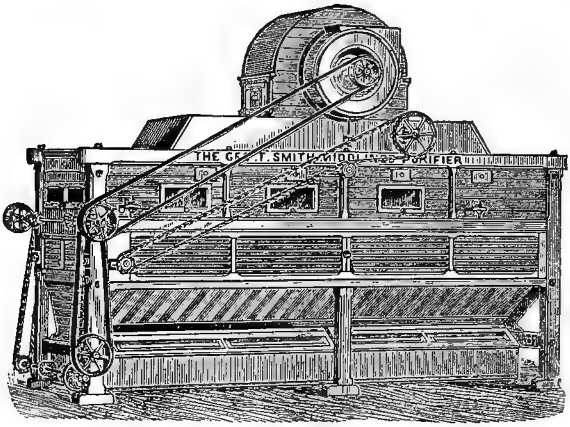
The several compartments over the sieve, having no communication with each other, each opening into the fan chamber by means of a valve which controls the flow of the air through each compartment separately, enables the operator to graduate the air currents used at different points on the sieve to exactly suit the specific gravity, size, or quality of middlings being treated. Without this subdivision of the chamber above the sieve and the command of the air currents which is thus secured, it is evident that if the air current used was of such force only as would suffice to remove the light impurities from the fine middlings, being sifted through the high numbers of silk at the head of the sieve, it would have no appreciable effect on the heavy particles of bran, etc., mixed with the larger middlings being treated at the same time on the coarser silk at the tail of the sieve; or, if the current used was of such strength as to remove the heavy impurities from the coarse middlings, it would at the same time take out and carry to the dust room the fine middlings from the head of the sieve, corresponding in weight or specific gravity to these coarse impurities. But with the graded and controllable air currents which these compartments and their regulating valves secure, a very gentle draught may



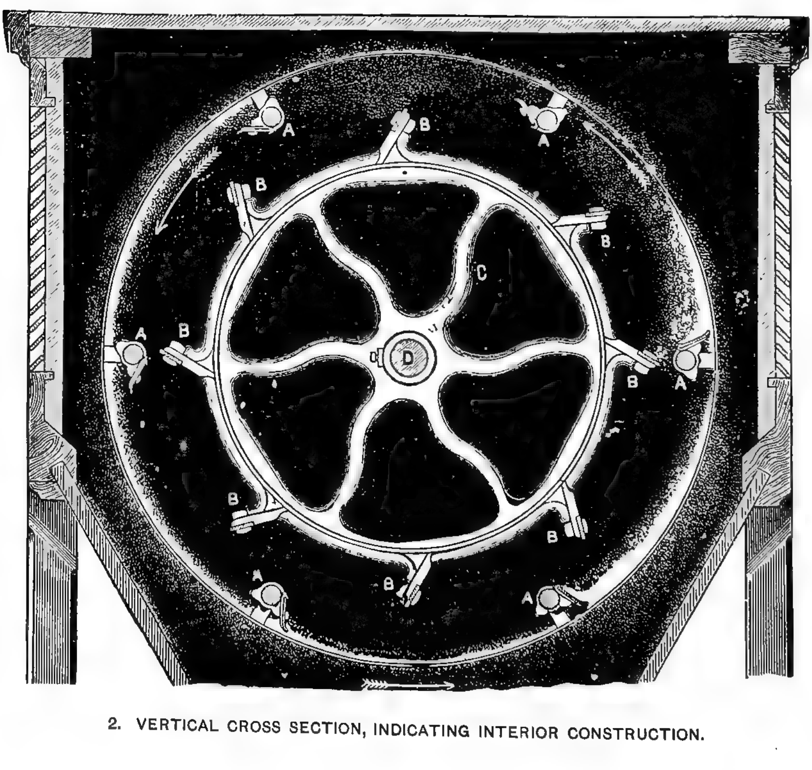
1. THE GEORGE T. SMITH MIDDLINGS PURIFIER.



2. ROBINSON'S MIDDLINGS PURIFIER.



1. MIDDLINGS PURIFIER, WITH PRINZ DUST COLLECTOR.



2. VERTICAL CROSS SECTION, INDICATING INTERIOR CONSTRUCTION.

be used at the head of the sieve where the fine middlings are taken through the silk, and the strength of the current can be increased in each succeeding compartment to any degree required to exactly suit the stock being purified, which constantly changes in character as it flows along from fine to coarse silk.

The pockets as at present constructed consist simply of drawers of suitable size on both sides of the machine, placed in the upper portion of the compartments just described, across the open tops of which the dust-laden air currents drawn up from the sieve are made to pass on their way to the fan, thus producing an eddy which causes the heaviest and best portions of the material carried by the air to be deposited in these drawers. Access to them is conveniently had from the outside of the machine, and by an examination of their contents the operator can see at a glance whether any good material is being taken out by the fan, and if so, from which section of the sieve it comes, thus having an unmistakable guide to the proper graduation of the air currents.

Hardly any single thing is of greater importance to the proper working of a middlings purifier than having the silk of the sieve stretched tight; but however tight the cloth may be when first put on, the elasticity of the silk is such that it must be tightened several times before "the stretch" will all be taken out of it. As most purifiers are constructed, nothing is more difficult and provoking than the process of tightening the silk, and for this reason it is apt to be put off as long as possible, waste and bad work resulting in the meantime. In the Smith purifiers the sieve frame, as now constructed, permits of the tightening of the silk on a sieve in two or three minutes at the most, the whole operation consisting in turning some half dozen thumb nuts, by which the tightening device is extended so as to give the proper tension to the silk.

In view of the imperative necessity of keeping the cloth on the sieve always tight, we consider this device one of the most valuable recent improvements in middling purifiers.

The value of the self-regulating feed in connection with a middlings purifier is so well understood by millers generally that it is unnecessary to enter into the question of its advantages here. The device for this purpose which we use is positively self-adjusting, and reliable in operation under all circumstances, is simple in construction, not liable to get out of order, and delivers the middlings to the machine evenly across the whole width of the sieve however light the feed may be.

The Prinz dust collector (Pl. XV, Fig. 1), exhibited in the American section, is a machine that performs the operation of exhausting the dust from middlings purifiers, roller mills, millstones, wheat separators, smutters, or any other machine that generates dust.

The cloth is cleaned by successive jarring (without moving the portion of the cloth thus being cleaned until the jarring ceases), combined with the air, which is reversed on that portion of the cloth, and the draft comes through the opposite way from which it cuts through into the fan, and by this action all the dust is retained in the machine.

It retains all the dust in the mill, thus allowing no waste of stock by being blown out into the air, as is the case with the old-fashioned dust room.

It does away with the liability of dust explosions, as the air coming from this machine is entirely free from dust.

"In the view of cross section (Pl. XV, Fig. 2) AA are the hinged elevators attached to the stay rods of the reel frame, for the purpose of carrying up the material as the cloth cylinder revolves, and delivering it to the spreaders or distributors, BB, on the upward-moving side of the reel. As the elevators complete the discharge of their load, they

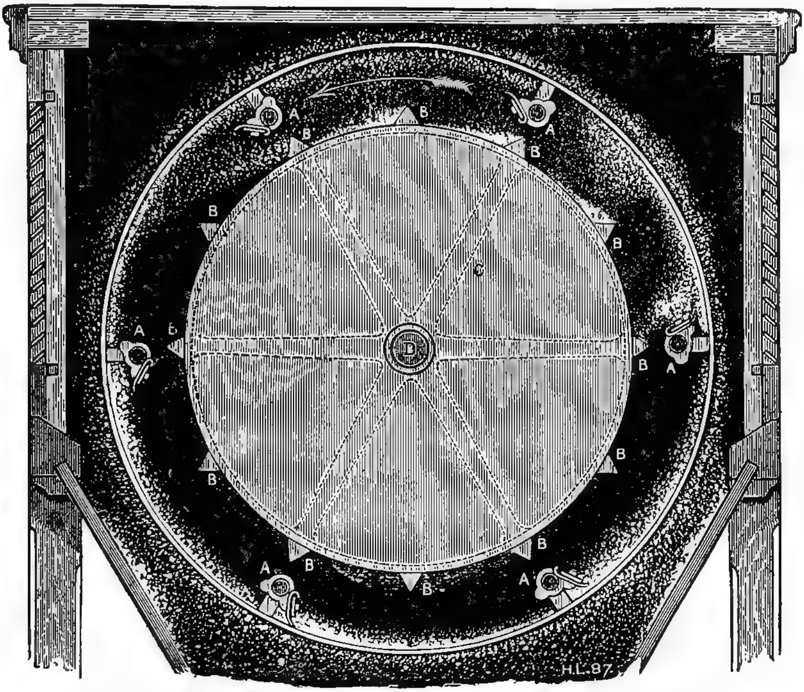
are arranged to drop automatically away from the silk, so that the material reaches the cloth behind them and is not obstructed in its travel around the silk cylinder; C is the spider to which the distributors are bolted, and D the distributor or driving shaft. The silk reel makes one revolution to twelve of the distribution shaft, or about eighteen per minute.

"In operating, the material being bolted is carried up by the elevators and gradually discharged on to the distributors, which, by their centrifugal action, spread it evenly over the entire silk surface. On the lower quarter of the upward-moving side of the reel, the bolting is affected somewhat as it would be in a round reel without the distributing cylinder; and the amount of work done on the section of cloth referred to would represent the entire bolting capacity of a round reel without distributors or elevators. From the center of the upper side of this reel, however, around over the top, and nearly or quite to the center at the bottom (this being the portion of the silk covering most distinctly exposed to the action of the distributors), the amount of work done is larger in proportion to cloth surface in the ratio of at least two to one than on the section first mentioned.

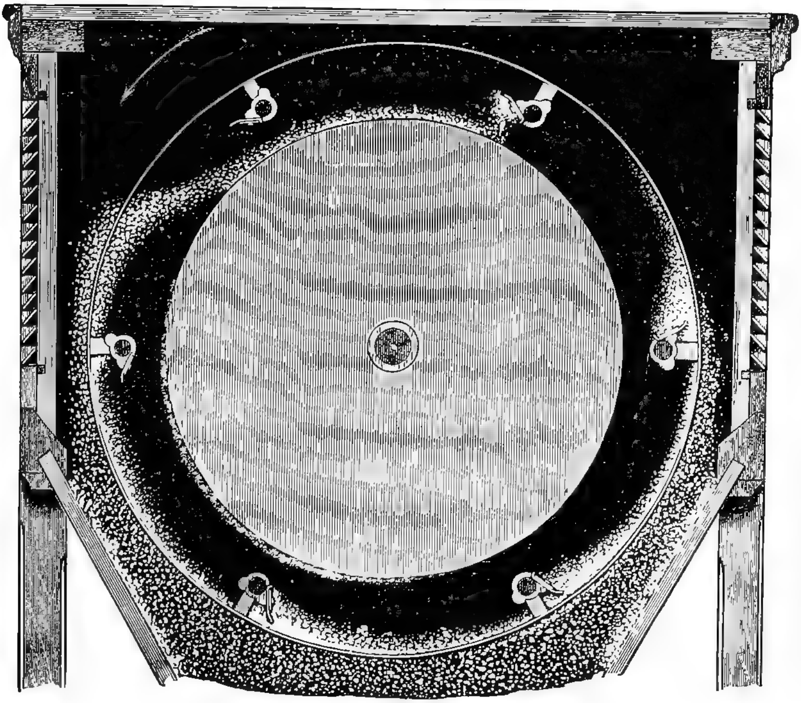
"The distributors deliver the material to the silk at a very acute angle, the apex of which is in the direction in which the cloth is moving, so that the bolting is effected almost entirely through the sliding movement of the stock over the cloth, and not by the material being forced through the silk, as is the case with the common reel.

An improved interior cylinder-bolting machine, adapted to handle to advantage different classes of material, is that represented in Plate XVI, Fig. 1.

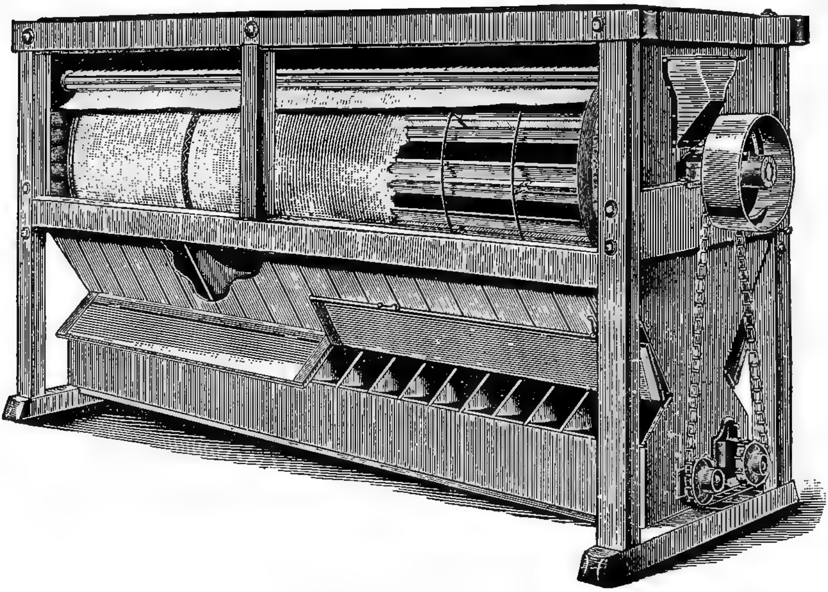
"Its working parts consist in a central closed drum or cylinder, C covered with sheet metal. On the outer surface of the drum are longitudinal elevations extending its entire length and arranged either parallel to its axis or in a spiral of such inclination as will best suit the kind and quantity of material to be treated. Swing elevators are loosely hinged to the stay rods of the outer silk-covered cylinder. This cylinder is mounted in bearings of its own and is connected by gears with shaft D of the interior drum, permitting a differential speed of any desired ratio between the drum and silk cylinder. The elevators A are arranged similarly to those in our centrifugal reel, and their office is substantially the same in both machines. With the inner cylinder running at about eighty per minute, and a differential of four to one, the machine is specially adapted for scalping the breaks from rolls. No. 1 size, 34 inches in diameter and 6 feet in length, has a capacity for any break in a mill of 1,000 barrels capacity.



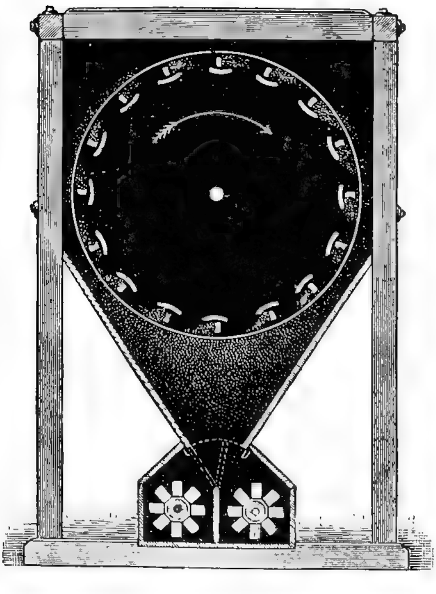
1. CROSS SECTION GEO. T. SMITH INTER-ELEVATOR FLOUR-DRESSER.



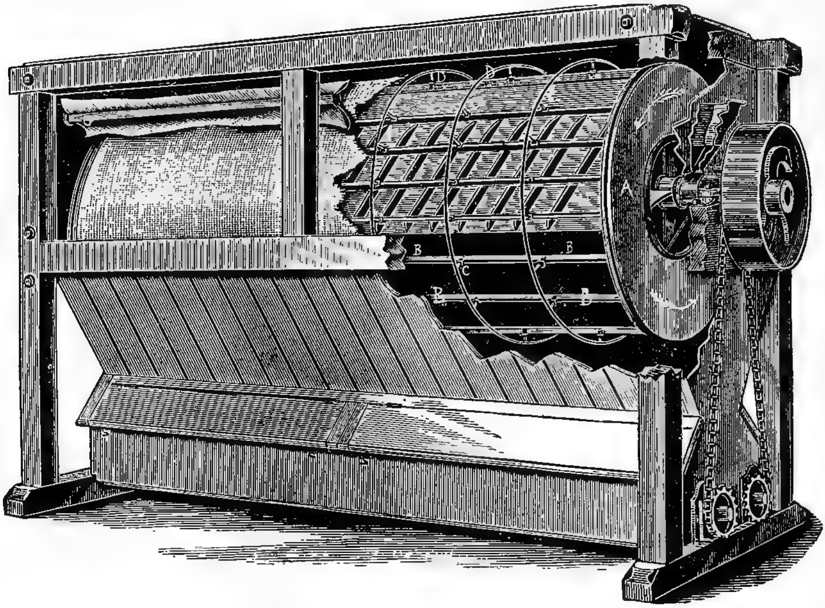
2. CROSS SECTION GEO. T. SMITH INTER-ELEVATOR REEL.



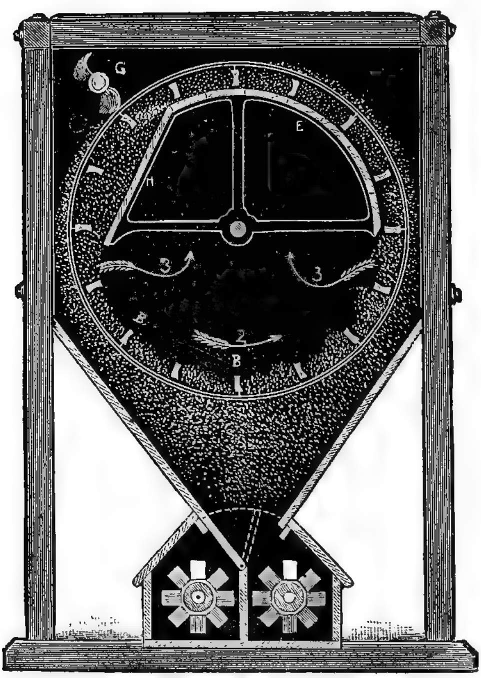
1. THE SILVER CREEK ELEVATOR SCALPER. VIEW OF HEAD, SHOWING CHAIN DRIVE ON DOUBLE CONVEYORS.



2. CROSS SECTION OF SCALPER, PARTIALLY INDICATING ACTION ON MATERIAL.



1. HEINE'S SILVER CREEK FLOUR BOLT.



2. CROSS SECTION OF HEINE'S FLOUR BOLT, PARTIALLY INDICATING ACTION ON MATERIAL.

"The Geo. T. Smith interelevator reel (Pl. xvi, Fig. 2) is constructed with an interior drum, covered with sheet metal, and about 6 inches less in diameter than the silk-covered cylinder which incloses it, both being keyed to reel shaft, and revolving at same speed. Between the drum and the silk are placed six to eight elevators of nearly the same length as the drum, which are loosely hinged to the stay rods of the silk-cylinder frame, and so arranged as to discharge their loads automatically when nearly above the drum. The material which would otherwise accumulate on the bottom of the reel is constantly carried up by the elevators, which cause a sliding motion of the stock against the cloth on the upward moving side of the silk, and discharge a large portion of their load on to the drum, at such a point on its surface as insures the stock being delivered from it to the cloth on the down side of the reel. The result of this arrangement is to constantly utilize nearly all the entire silk surface for bolting, to prevent undue accumulation of material at any point in the reel, lessen the power required to drive the machinery, and add to the life of the silk covering by distributing the wear on it evenly.

"The machine has large capacity, handles the stock very gently, and runs easily. It is specially adapted to scalping breaks of wheat or middlings sizing rolls, and to bolting rye, buckwheat, and cornmeal chop, but we do not recommend it as a flour-dresser. It is made with counter and spur gear, with cross shaft and bevel gear, or to drive by sprocket wheel placed directly on the reel shaft. This last arrangement permits of its being driven from any shaft, making twenty to forty revolutions per minute."

The scalper exhibited by Aug. Heine, of Silver Creek, New York, (Pl. xvii) has a cylindrical wheel inside of which there are a series of narrow elevating strips as long as the reel, and traveling within one inch of the inside of the cloth surface. Back of these strips, and within three-fourths of an inch of them, are placed covered strips the full length of the reel and serving as deflectors of the grain. The elevating strips and deflectors travel in the same direction and at the same speed as the cloth. "The material to be treated is spouted to the machine, entering which it drops by gravity towards the bottom of the reel, but its direct fall upon the cloth is prevented by the elevators and deflectors. These deflect the course of the downward pouring stream of material, and diverting it in the direction of the travel of the cloth scatter it by gentle action over a considerable area, and separation by sieving action is at once begun. Undue accumulation of the material upon any part of the cloth is prevented by the elevators, which, picking up the surplus of the material, carry it up to almost the highest point of the reel, gently tossing it meantime against the cloth."

The flour bolt made by August Heine, Silver Creek, New York, is shown in Plate xviii.

"Inside the cylinder is a stationary arch or bridge, the radius of which comes within one-half inch of the travel of the elevators. On the upgoing side this bridge forms the part of a true circle, but from a short distance past the highest point on the down-going side it has a flat surface (H), upon which are placed adjustable slats or gates (FF), by means of which the travel of the material being treated can be regulated. The machine has central feed, and discharges by means of elevator arms into a spout at the tail end. For the purpose of cleaning the cloth there is a whipper (1), which gently taps or whips the cloth, and prevents clogging of the wheels. The motion of the cylinder is from twenty-four to thirty-four, according to size."

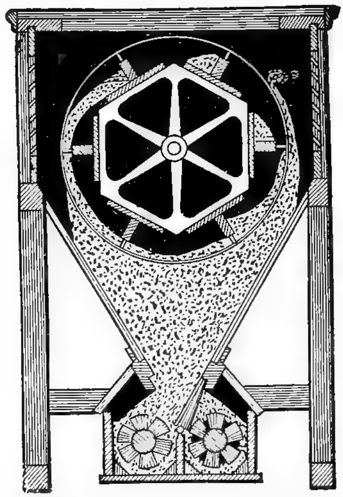
"In operation the flour is fed into the cylinders and by the elevators (traveling in the same direction and same speed as the cloth) is carried up on the up-going side where there is a continual current toward the cloth causing a gentle, dashing action. After the elevators pass the lower edge of the bridge (E) the tendency of the dropping flour is inward, and the space between the elevators and the bridge will allow a portion of the flour to drop down, and this dashing operation is repeated nearly up to the highest point of the bridge. All flour carried past this point is precipitated on the downward side where the flat surface (H) begins, and being followed by the elevators is here too repeatedly dashed toward the cloth, so that we utilize continually nearly four-fifths of the entire cloth surface.

"The gentle dashing action referred to liberates the specks in the flour, and they being specifically lighter, readily float into the large eddy formed under the bridge and indicated by arrows 3 3, where, with the gentle current moving there they drift toward the discharge.

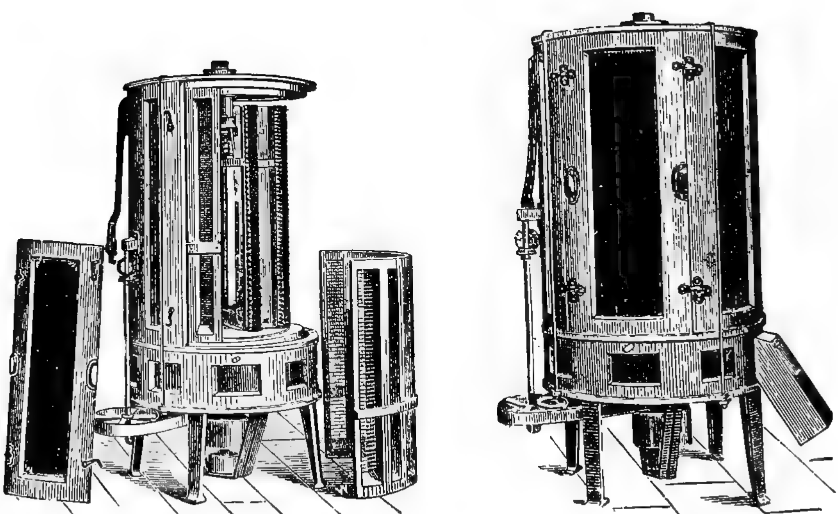
"The action upon the material under treatment is continuous. The whole of the material is broken up, disintegrated, and is kept in constant agitation, being gently, yet always effectively, dashed against the cloth surface in a thin shower or sheet or mist. Light impurities are, by the action of the elevators, kept always in suspension, and as they work toward the tail of the machine they drift into the slight eddy formed under the bridge (E), and are floated out."

The centrifugal reel exhibited by the Excelsior Works, Silver Creek, New York, is arranged so as to prevent the surrounding air from entering at the head and tail of the machine. The central discharge is connected with a valved outlet, the valve being held tight by the rarified air in the reel, and opening on the weight of the meal becomes sufficient to overcome the atmospheric pressure.

"The material to be treated on a centrifugal, being of all sorts and kinds, should be well disintegrated and sifted for the purpose of preparing it for treatment and removing dough balls or other foreign substances before bringing it in contact with the cloth. We therefore devised a conveyor brush, acting upon a trough of very heavy wire cloth, of such mesh as would readily allow of the flour being



1. SECTIONAL VIEW OF BOLTING REEL.



2. THE EXCELSIOR BRAN DUSTER.

sifted through, while dough balls or other material injurious to the bolt cloth would be carried on by the lead of the brush, and finally rejected over the end of the wire cloth, to be ejected by a drop valve. Below this brush and wire trough a conveyor is placed for the purpose of conveying the material to spouts which feed it centrally to the reel, where it is taken up by the distributer and thrown out to the reach of the beater cylinder. This mode of feeding is much to be preferred to crowding the meal through a tube by means of a screw, whereby it is packed into hard lumps, and so fed to the reel. The feed arrangement is, as nearly as it can be, air tight.

"The cloths are made in two sections, held in place on the ends by wire hoops on tapering flanges, and joined together over the middle iron band by lacing over open hooks. This is decidedly the simplest and most expeditious mode of putting on cloth, and does away with the complication of screws and stretchers, while we have the advantage of being able to change either portion of the cloth without disturbing the other.

"The conveyors are placed side by side and run in our improved box, by which absolute control of the cut-off is assured.

"The machine is supplied with our improved cloth-cleaner, which keeps the meshes, at all times, open and free without the slightest wear on the cloth surface. This cleaner is in the nature of a whipper, which, while gentle and soft, is completely effective in its action, taps the cloth lightly, forcing back any particles of the stock that temporarily lodging in the meshes. By our method of securing the beaters to the spiders all liability of their becoming loose is absolutely avoided. The angle at which the beaters approach the material is also a noticeable feature, as delivery of the material to the cloth is effected in spray, thus ass uring positively a clear bolting over the entire cloth surface. This positively even distribution of the material under treatment obviates all necessity for auxiliary elevators or 'pick-ups,' found essential on some centrifugal reels to relieve the cloth of accumulations detrimental to a free bolting capacity.

The bolting reel shown in Pl. XIX, Fig. 1, differs from those already described in the construction of the elevators. "The material, when introduced, is prevented from accumulating in deep bulk by the lifters, the edges of which come within about 1 inch of the bolting cloth, they serving to gather up and relieve the bolting cloth of the heavy bulk of material, only leaving such an amount to slide on the cloth as will pass through the 1-inch space between the lifter and the cloth, thus producing a very gentle sliding action. The material which is carried up by the lifters, when at a certain height and angle, falls into pockets formed by the lifting ribs and aprons, and is carried over to the down side of the reel, and discharged there against the bolting cloth. After being carried over the material moves in an

elliptic curve, and attains a slightly greater speed than that of the cloth at the point of junction, which point is about 45 degrees from the horizontal axis of the reel. This result is attained by giving the pockets the proper form, the reel a certain speed and centrifugal force in connection with the force of gravity."

The illustrations show the iron-cased bran duster, made by Aug. Heine, at Silver Creek, New York, and intended to collect flour from the bran, and it is said to be adapted also for handling germs from smooth rolls, either direct from the rolls or after passing through a bolt.

The action of the brushes on the flattened germs before they become quite cold and brittle removes all the flour, and the germ is discharged flat as bran.

The horizontal bran duster, shown in Plate XX, Fig. 1, was operated in Robinson's mill and seemed to do its work well, dusting the bran without cutting it up. The machine was gentle in its motion and made the bran broad and clean.

Brault, Teisset & Gillet, of Paris, exhibited a dust collector (Pl. XX, Fig. 2) of simple construction and easy to work.

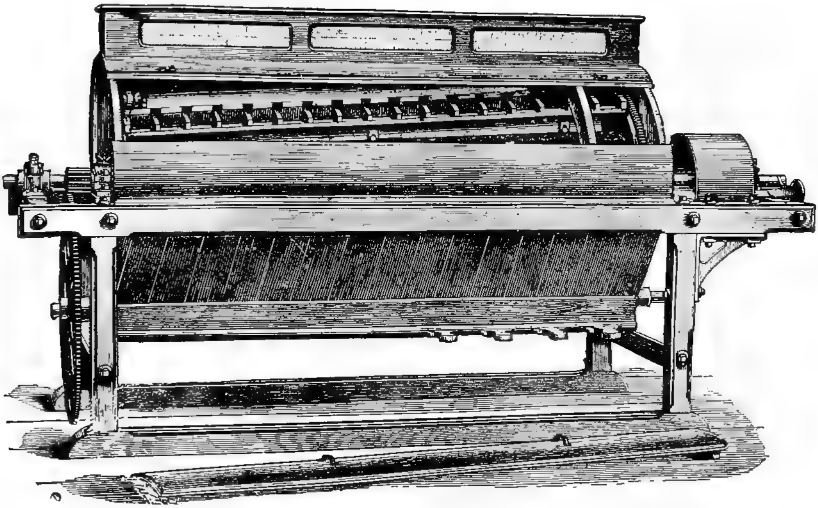
(7) ROLLER MILLS AND OTHER GRINDING MACHINES.

Among the English exhibits was one by J. H. Carter, of London, showing various kinds of flour milling apparatus. Especially worthy of attention were some roller mills with four cylinders (Plate XXI). The rolls are made of cast-iron tempered to a considerable depth, as shown in the illustration. There are three rolls superposed, with a device to adjust the pressure of one upon another.

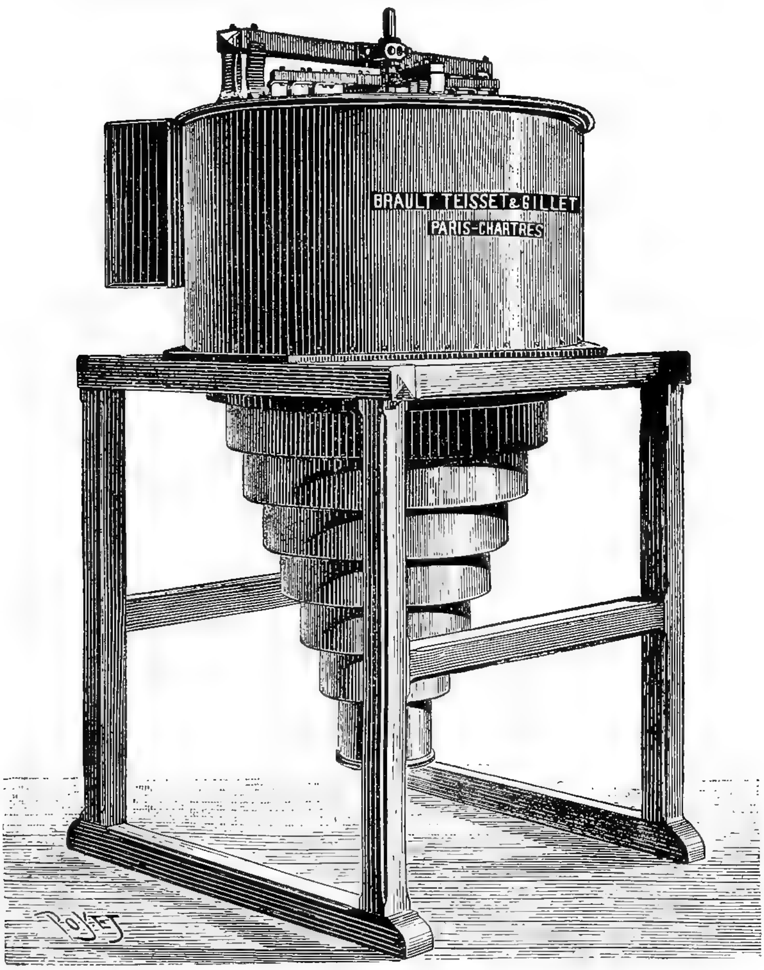
The credit of the invention of metallic rollers is claimed by Switzerland, where they were first used about 1832, then in Austria and Hungary. In 1870 successful trials were made with porcelain rollers. The great millers of Europe are now generally agreed that the milling by gradual reduction with rollers is the best process, and that in no other way can the best flour be obtained.

The first-break roller mill, exhibited by Thos. Robinson & Son (Pl. XXII), is designed to split the grain through the crease and to remove the dirt and dust lying in the crease. It consists of three rolls, the centre one being fixed and the two outside ones revolving at a high speed against it. The length of the rolls are from 6 by 12 inches to 9 by 24 inches, and vary in speed from 400 to 450 revolutions a minute.

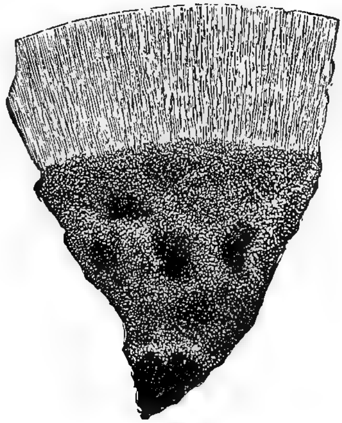
The automatic feed, exhibited by Thos. Robinson & Son (Pl. XXIII, Fig. 1), is intended to spread the grain regularly and evenly over the full face of the roll. A is a hopper, to which the spout is attached, which feeds the machine, B is the vibrating sieve on which the stuff falls from the hopper A, motion being given to the sieve by the eccentric shaft C, against which it is pressed by the spring D. When the

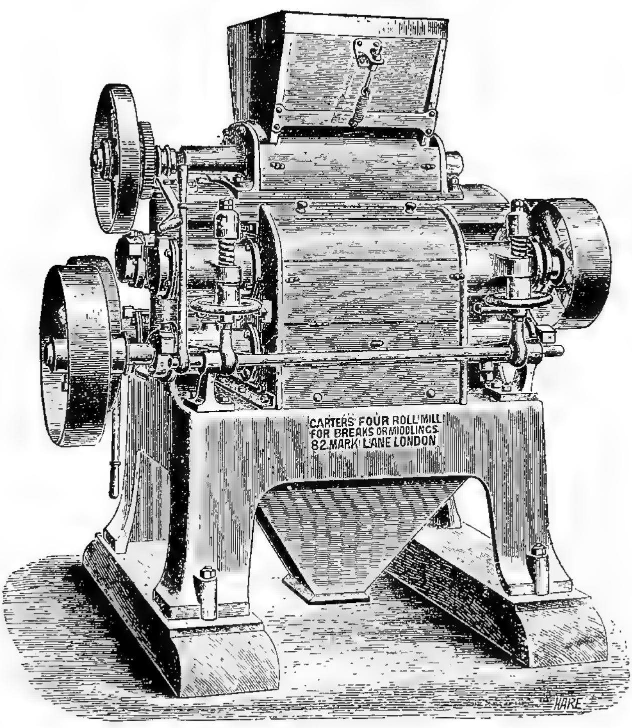


1. BRAN DUSTER.

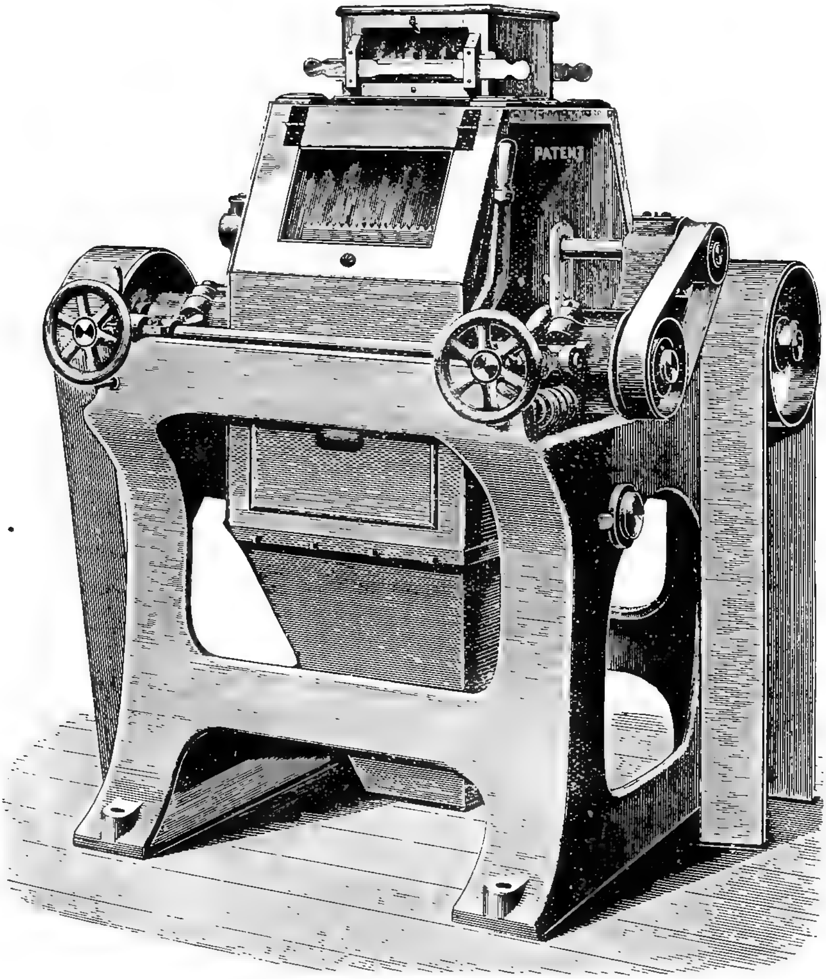


2. DUST COLLECTOR.

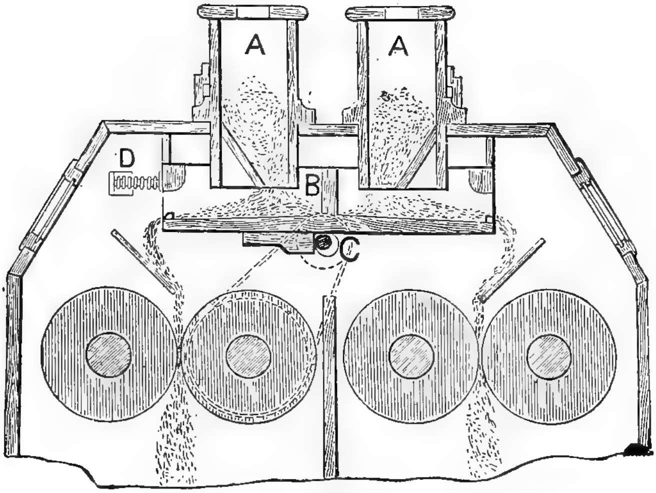




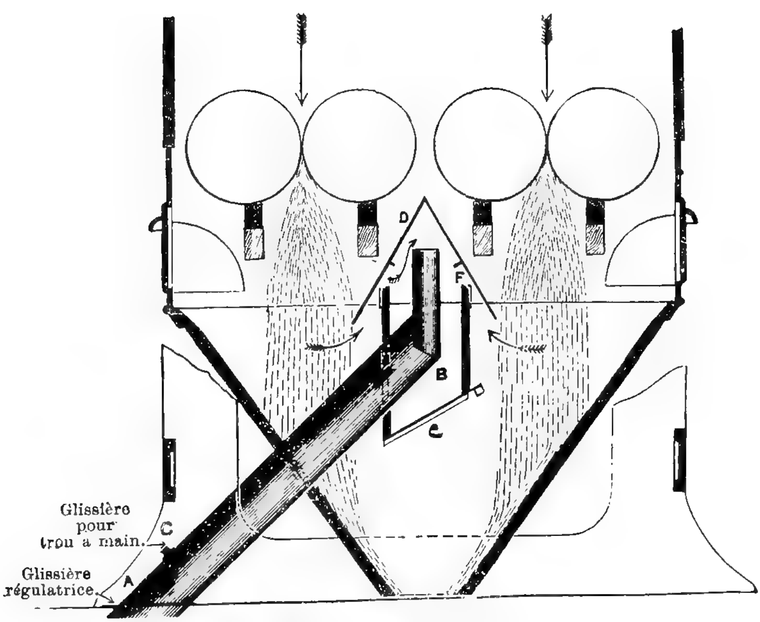
CARTER'S ROLLER MILL. PIECE OF CYLINDER SHOWING DEPTH OF CHILLED IRON.



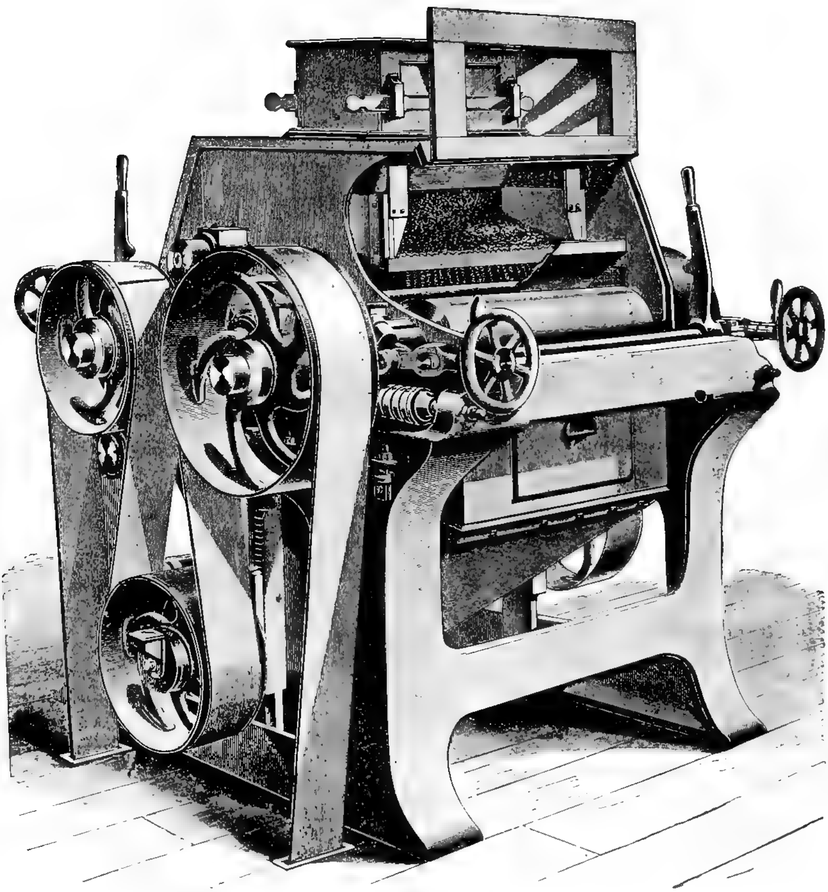
ROBINSON'S FIRST BREAK ROLLER MILL.



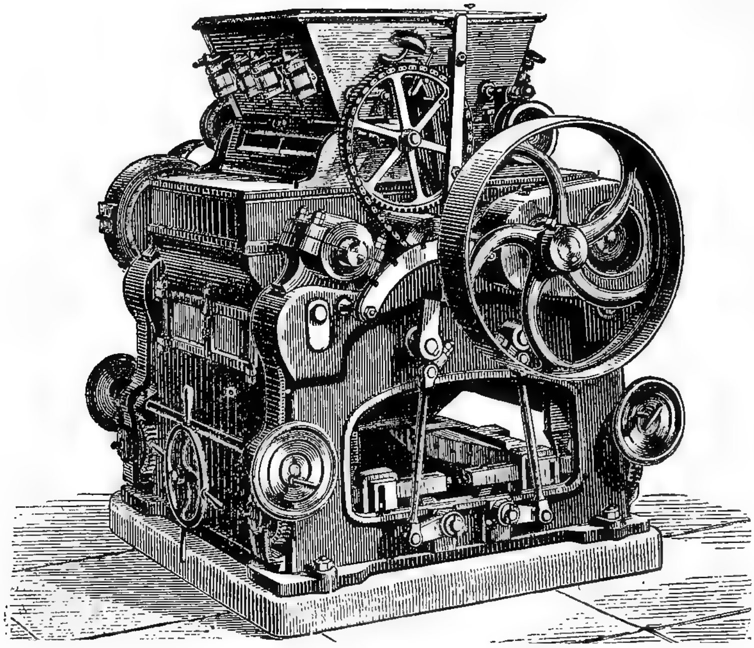
1. AUTOMATIC FEED.



2. ROLLER MILL WITH EXHAUST PIPE.



ROBINSON'S HORIZONTAL ROLLER MILL.



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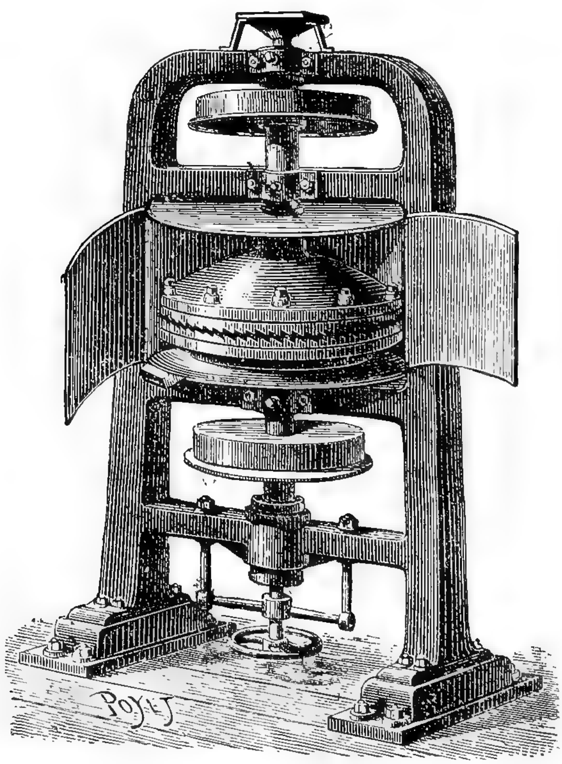
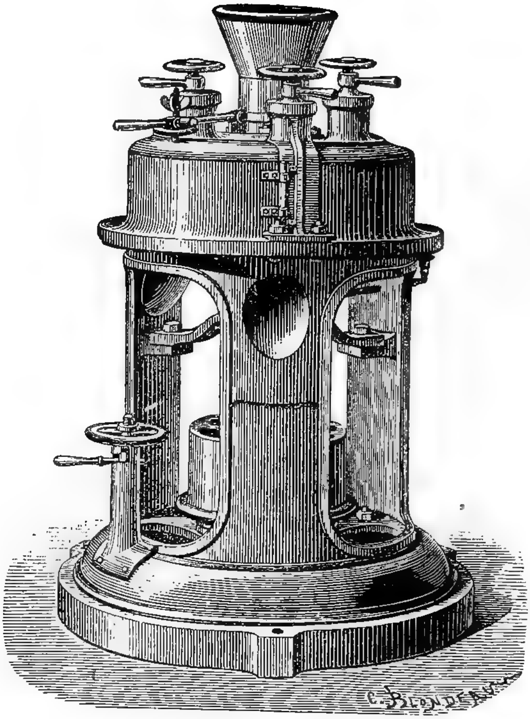
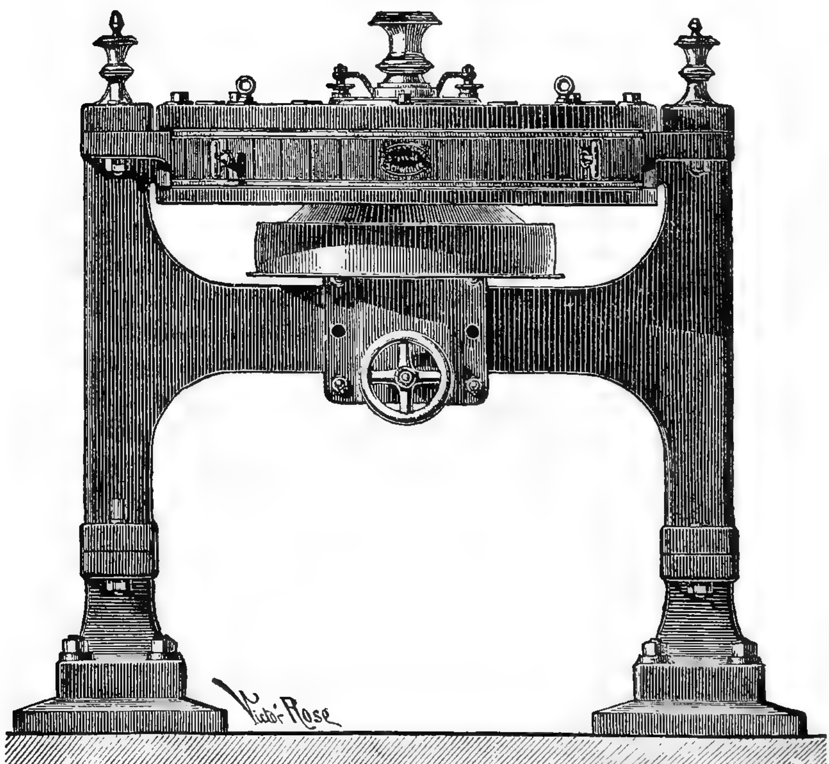


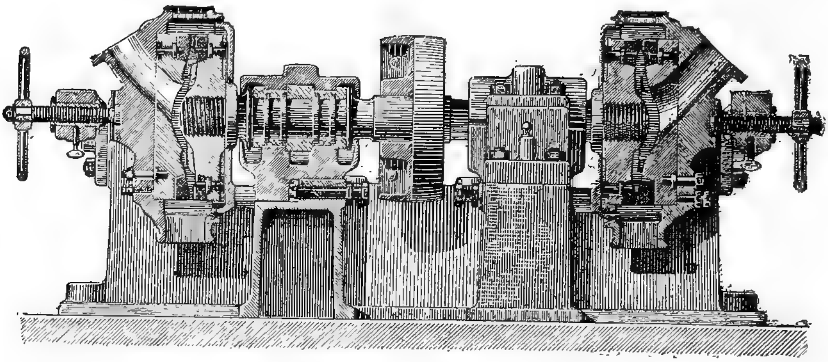
2

SCHWEITZER BREAK MILL.

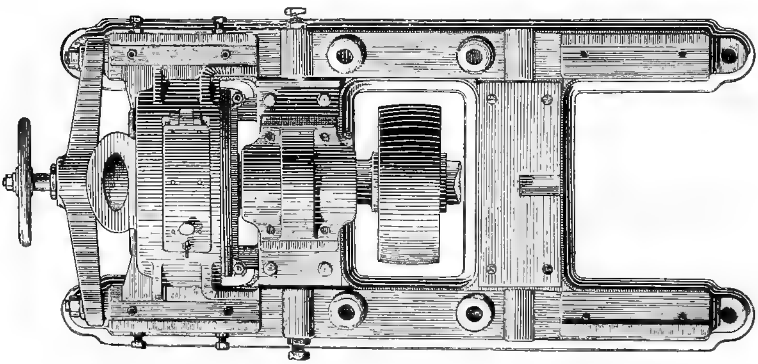


1. LEGRIS METALLIC DISK MILL.

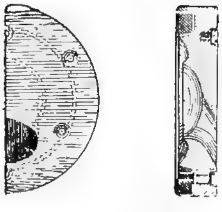




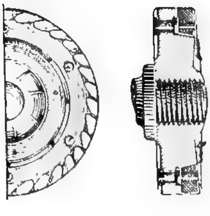
Vertical section.



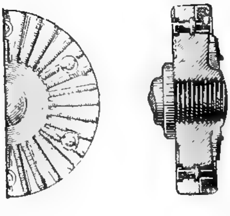
Plan.



Disk turning to right.



Fixed disk.



Disk turning to left.

GUILLAUME MILL.

eccentric shaft revolves rapidly a continuous stream of grain falls evenly upon the whole middle of the rolls.

An exhaust pipe is set beneath the rolls to withdraw the heat that accumulates and may injure the quality of the flour.

As shown in the illustration (Pl. XXIII, Fig. 2) A is the exhaust pipe; B is an expansion chamber where the exhaust is applied and has a sliding bottom, also an adjustable hood, D. When the exhaust is applied the air is drawn through the contracted space F, as shown by arrows, and as soon as it enters the box or chamber B it expands, and thus any good stock that is drawn through F immediately drops to the bottom of the box, while only the hot air and light impurities pass down the exhaust pipe A.

The horizontal roller mill, exhibited by Robinson (Pl. XXIII, Fig. 2), was furnished with the automatic feeder and the automatic exhaust already described.

The rolls vary in size from 6 by 12 inches to 9 by 30 inches. The break rolls have a speed of 30 to 400 revolutions for the fast rolls and 120 to 160 revolutions for the slow rolls. The smooth rolls run from 300 to 350 for the fast, and 250 to 280 revolutions for the slow rolls.

These horizontal roll mills are made with either two rolls or four rolls.

A. Malliary, of Essonnes, France, exhibited a combination roller mill of very superior construction, carrying two pairs of 25-inch rolls and two pairs of 13-inch rolls. The reduction of the wheat into flour is accomplished by four or six passages through a single machine. The adjustments are very accurate in their action, so that the rolls may be brought as near together as desired in regulating the pressure on the grain. The larger rolls for fine grinding are of porcelain, and the break rolls of cast iron. (Pl. XXV.)

Laurent Frerès & Collot, of Dijon, had an exhibit of roller mills and also of other kinds of milling machinery, all of excellent construction.

The Schweitzer system of milling is to use metallic plates or disks, both for breaking the grain and for grinding into flour. Great economy of space and a quality of flour superior to that obtained by mill stones or roller mills are vigorously claimed by the inventors of this system. I show the break mill in Plate XXV, Fig. 1, and the reduction mill in Plate XXVI, Fig. 2.

Another system of milling with metallic disks was exhibited by Edouard Legris & Co., of Rouen. The lower disk rotates, while the upper one is fixed. (Pl. XXVI, Fig. 1.)

The same establishment also exhibited roller mills, with rolls in metal and in porcelain.

The Guillaume system of milling attracted some attention as a novelty, and prominent millers expressed much satisfaction with the work done by these mills. The illustrations (Pl. XXVII) show

the general construction of the mill. There are two metallic corrugated steel disks, one at each end of a shaft, which is turned by a belt at the middle of the shaft. Opposite each disk is another disk that may be adjusted to any desired distance from the movable disks that make five hundred turns a minute. There are thus two mills that may be adjusted to work the same product, or two different sizes.

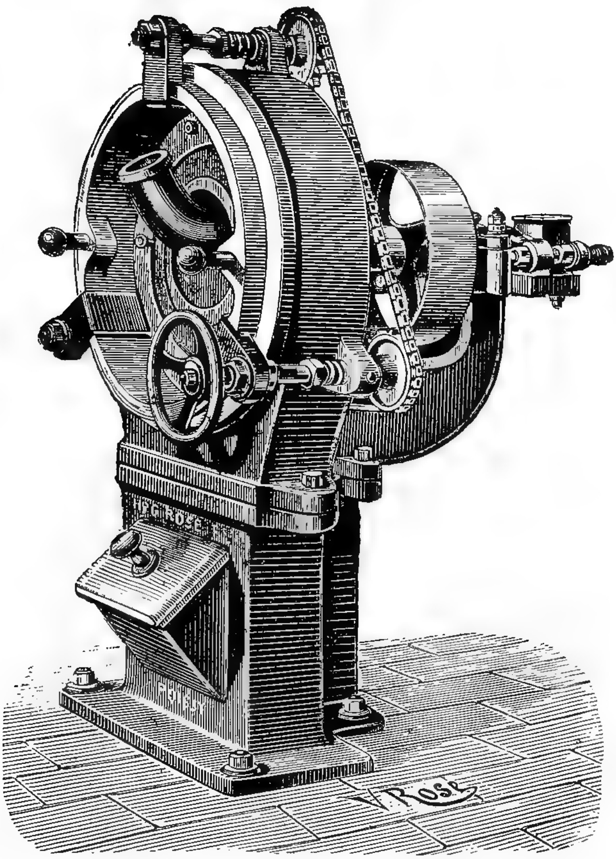
The entire apparatus is about 45 inches long, 20 inches wide, and 20 inches high. The apparatus is specially adapted to the preliminary breaks in the gradual reduction of wheat, the final conversion in flour being done by steel or porcelain roller mills, or with grindstones. Similar mills are made for grinding other grains, and for use by starch and paper manufacturers.

There was a very complete exhibit of milling machinery made by Rose Frères, of Poissy, France. The apparatus was in operation each day, turning out excellent products. One of the machines shown was a breaker or granulator of simple construction, intended for small mills. The wheat is passed through the machine twice, the first passage simply splits the berry in the crease, and the second further crushes and frees the germ. The chop is then separated into bran, flour, and middlings, and the latter are cleaned and ground in the roller mill in fine flour. Plate XXVIII shows one of these granulators with the front plate removed. They are made in two sizes, the larger requiring an expense of 2 horse-power breaks about 250 pounds of wheat an hour. Plate XXIX is a roller mill exhibited by the same manufacturers.

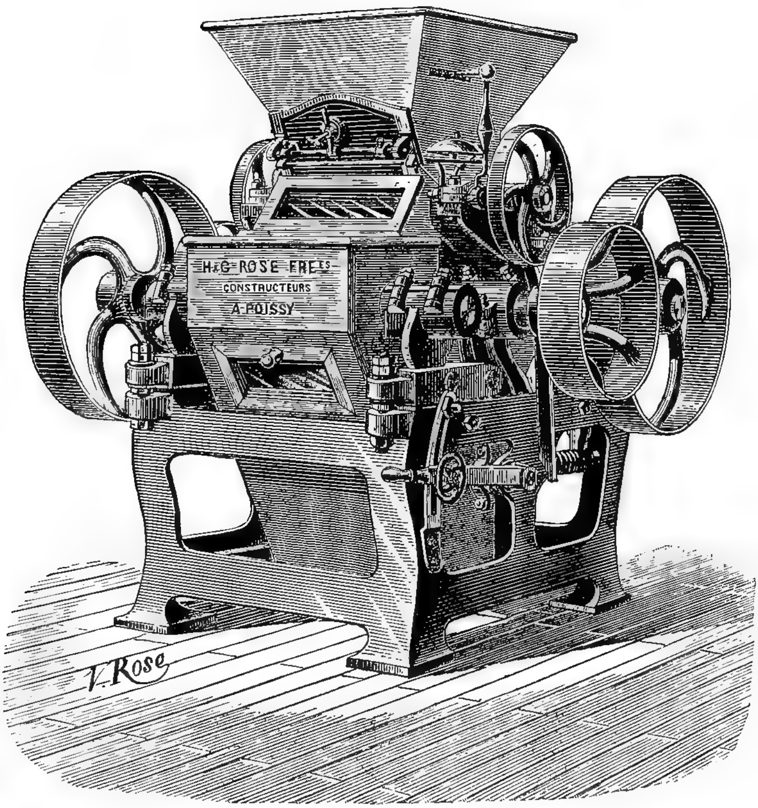
Fr. Wegmann, of Zurich, exhibited some porcelain roller grinders of excellent construction. (Pl. XXX.) The "Victoria" is furnished with two rolls about 16 inches long and 13½ inches in diameter, and is adapted to the reduction of the first flour. Its capacity is from 300 to 500 pounds of flour per hour. Larger sizes were also shown, the rolls about 40 inches long and 13½ inches in diameter, with a capacity of 800 to 1,000 pounds of flour per hour.

Roller mills are employed in the United States in making fine corn meal. The shelled corn is ground between two pairs of corrugated rolls, one pair above the other. In passing through the mill the corn suffers two reductions, the first breaking the corn into coarse grits, and the second reducing the grits to meal. The rolls may be adjusted to make any desired fineness of meal. After being ground, the product is bolted, graded, dusted, and purified.

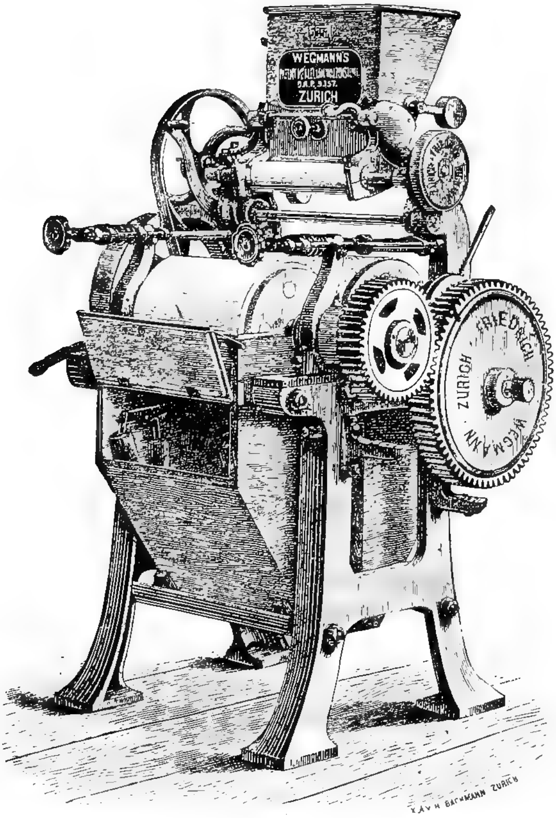
The new process buckwheat flour, made by American millers, is prepared by first subjecting the grain to a separator and scouring machine. It is then passed through the shucker, which takes off the black, woody outer hull and the inside skin. The white meats, or kernels, are then ground between rolls to separate the flour, and the middlings are again ground and bolted.



ROSE FRÉRES GRANULATOR.



ROSE FRÉRES ROLLER MILL.



WEGMANN'S DOUBLE ROLLER MILL.

MILLSTONES.

Although most of the grinding is now done by steel or porcelain cylinders instead of millstones, yet it is an open question whether the cylinders are actually better for all parts of the work. There are many who claim that for finally grinding the middlings into flour the stones are preferable. There was a large exhibit of millstones in the French section. A quality of stone peculiarly well suited for mills is obtained at the quarries of Ferté-sous-Jouarre, near Paris. Nearly all the population of this locality are employed in quarrying the stone, and in shaping it for millers' use. On account of the structure of the stone, which contains cavities formerly occupied by fossils, it has been found necessary to make up a grinding-stone of several pieces fitted together, rather than of one solid piece. The dressing of the stone is important. There are very many forms for the furrows or channels. The raised parts between the channels called "land," crushes into powder the slices of wheat formed by the furrows.

Improvements have been made toward the proper ventilation of the grain during the grinding operation.

The Société Genéralé Mèuliere, made a complete exhibit of milling machinery, but more especially of millstones from the world-renowned quarries at La Ferté-sous-Jouarre and at Epernon. Besides the ordinary millstones, there was shown a granulating mill used in the gradual reduction system to split and break the grain before grinding it into flour. This establishment exports annually about seven thousand millstones, besides 7,000 to 8,000 tons of rough stones to be made up in foreign countries.

CLASS 68.---PRODUCTS OF THE BAKERY AND PASTRY SHOP.

CLASS 68.—PRODUCTS OF THE BAKERY AND PASTRY SHOP.

I.—THE AWARDS: REVIEW OF EXHIBITS.

In Class 68 there were about one hundred and twenty exhibits, more than one-half of which were in the French section. The awards included 1 grand prize, 11 gold medals, 36 silver, 48 bronze, and 15 honorable mentions, as follows:

	Grand Prize.	Gold Medal.	Silver Medal.	Bronze Medal.	Honorable Mention.	Total.
France	1	9	16	24	12	62
Netherlands			6	2		8
Algeria			5	1		6
Switzerland				6		6
Italy		1	1	3		5
Japan			1	4		5
Austria			2	1	1	4
Belgium			1	1		2
Spain				2		2
Great Britain		1				1
Finland					1	1
Argentine Republic			1			1
Denmark					1	1
Tunis			1			1
Norway			1			1
Chile			1			1
Egypt				1		1
Grand Duchy de Baden				1		1
Réunion				1		1
United States				1		1
						111

A grand prize and gold medal were awarded to the manufacturers of Olivet biscuits. A gold medal was given to the London manufacturers of Spratt's food tablets for the army and navy, and to Macfarlane, Lang & Co., of Glasgow, for their fine collection of biscuits, cakes, and Scotch short bread.

The firm of Joseph Baker & Sons, London, had a very complete exhibit of kneading machines, ovens, biscuit machines, and all kinds of apparatus used by bread and pastry bakers. They operated the machines daily, producing excellent qualities of wafers and cakes in

great variety, but as these products were simply to show the working of the machines, they were not in competition. The machines were awarded a gold medal.

The display of bread and pastry in the French section was very complete, including plain and fancy breads, biscuits, and cakes in bewildering variety. The Argentine Republic made a display of crackers and Austria-Hungary showed some fine pastry and fancy cakes.

The exhibitors of Belgium in this class were only three in number, but the samples of bread and biscuit shown were excellent in quality and appearance. The firm of H. Vanneste-Busschaert, of Bruges, showed some fine biscuits, adapted especially for desserts.

Bread in Belgium, as in France, is really "the staff of life." It is not eaten simply to accompany other foods, but is one of the principal foods. Great improvements have been made in bread-making in the past twenty years, and especially in the past ten years. The bakeries are divided into four distinct classes: Fancy breads (*pains de luxe*), ordinary family bread, pastries, and spice cakes. In different parts of Belgium the kinds of bread vary much. Brussels, Liege, and Antwerp each have their specialty. Antwerp has a bread made of wheat and rye worked separately and then mixed in a particular manner, and which is supposed to possess qualities particularly nutritive and digestive. I have been unable to find the exact recipe for this bread.

In Belgium, as in France, they make a great deal of molasses cake. The center of the industry in Belgium is at Gaud; in France it is at Dijon.

Antwerp is known for a specialty called "spekulatie." Chile exhibited some crackers; Denmark some bread for dyspeptics; Egypt, pastry; Spain, crackers; Italy had an exhibit of a large variety of fancy cakes, crackers, and breads; Japan had some samples of bread and some cake made from millet. Norway had only one exhibit of crackers. Holland had several exhibits of fancy bread and cakes, and some delicious crackers for children and invalids. Portugal showed some pastry. From Finland there were three interesting exhibits of rye and wheat breads, crackers, and some sweet black bread. Salvador exhibited some pastry, and Mexico some corn bread and crackers. Switzerland had some compressed biscuits for military campaigns, and some fancy pastry and crackers.

From the United States the only exhibit in this class was some baking powder by the Queen City Chemical Company. It is very much to be regretted that some of the cracker and cake makers of the United States did not make displays to show what great progress our country has made in these industries.

II.—HISTORY OF BAKING.

KINDS OF BREAD AND PASTRY.

Among primitive people, bread-making was the work of the women in each family. The ancient Egyptians were well versed in the baker's art. The Romans, at the beginning of the Christian era, had special artisans for making ordinary bread and fine breads made with milk, butter, and eggs.

The bread most sought for by the Romans was made from dough with raisin juice, and they soaked it in milk for eating. About 70 years ago, a building was unearthed at Pompeii with a sign reading "public oven" and near by was a "baker's shop." In the room were jars of wheat and flour. The millstones were in those days turned by asses or by slaves condemned by punishment to this work. On the wall of a room in the baker's shop was pictured an ass, and under it the inscription—probably written by a freed slave—*Labora, aselle, quomodo laboravi, et proderit tibi* (Work, poor little ass, as I have worked, and it will be of service to you).

The old saying is still true—potatoes for the Irishman, macaroni for the Italian, and bread for the Frenchman. The French laborer in the country eats 700 to 800 grams, and in the city 500 grams of bread, while the average individual consumption in Paris is 430 grams per day, and the general average for all France is estimated at 580 grams, representing 450 grams of flour. The total annual consumption of bread in France is given as 8,045,000,000 kilograms. There are upwards of 1,500 bread bakeries in Paris, besides very many pastry bakers.

Gluten bread and a bread without crust, made from gluten flour, is used in the Paris hospitals for diabetic patients. The gluten bread is made by taking 2 pounds of gluten flour, fresh yeast the size of a filbert, with a little cold water and two pinches of common salt. These are mixed, and enough warm water at 95° to 105° F. is added to make the dough of proper consistency. After fermenting from 1½ to 2 hours, the dough is cut into cakes, rolled in gluten flour, and baked as ordinary bread.

Potatoes added to wheat flour, in proportion of two-thirds flour to one of potatoes, gives an excellent quality of bread.

Bean flour is used to some extent in the preparation of fine breads. In some countries they add to the wheat flour one-tenth of bean flour, and make a bread rich in nitrogen, white, and very nourishing.

Corn flour makes good bread if you mix with it one-third its weight of wheat flour, or wheat and rye mixed, preserving the proportions as above.

Bread made from buckwheat flour is healthy, but it does not keep its freshness, and crumbles even the next day after being baked. The French generally mix rye to buckwheat, which keeps it in better condition.

It appears nearly impossible to make bread from rice alone. They have tried to introduce in the dough a certain quantity of cooked rice, but as it contains only a very small amount of nitrogenous material, it makes a flat loaf, indigestible and watery. Experiments have shown that a bread of good quality and nutritious may be made from wheat and rice in proportion of six parts wheat to one of rice.

Wheat and rye mixed in proportion of two parts of the former to one of the latter, makes a good bread.

Barley flour contains less gluten than wheat or rye. The bread made from this flour alone has a crumb that is neither flexible nor spongy; it is often dry and brittle. When wheat or rye are mixed with the barley, it is more agreeable.

Rye bread is next in importance to wheat bread. It will keep fresh longer than bread made of wheat. When well made it has an agreeable taste and digests easily, but when poorly made, it is heavy and hard to digest. In rye there is much less gluten than in wheat. It requires strong yeast and a shorter kneading with tepid water. The raising takes less time, and the time for baking is much less than for wheat bread, but the oven must be hotter.

Wheat flour is mostly used in Paris, but there is also used a small amount of rye, corn, barley, and buckwheat.

Three-fourths of the soldiers of the French army receive their bread and biscuit from the Government bakeries, of which there are 86 in France and 30 in Algeria. At the army bake-shop in Paris, 15,000 loaves or 30,000 rations of bread are cooked each day for the garrisons in Paris and vicinity. This shop produces 6,900,000 rations of bread, and 2,800,000 kilograms of biscuit, each year, consuming 11,000,000 kilograms of flour produced from 15,000,000 kilograms of wheat. Both hard and tender wheats are employed, either in proportion of one-half of each, or two-thirds tender and one-third hard. In the Algerian bakeries hard wheat only is used. The hard wheat comes from Algeria and other French provinces ; the tender wheat is either native or foreign grown. The dough is kneaded by machinery in Paris, and in some of the other military shops. The standard loaf weighs 3.3 pounds, or two rations. The common form is round, its diameter about 11 inches, and its height about 4 inches. The whiteness of the bread and its taste are intermediate between the first and second quality breads of the civil bakeries. The product of 100 kilograms of tender wheat flour is 139½ kilograms of bread, and 150 kilograms of bread from hard-wheat flour. Besides loaves of bread, the army bakeries make "hard tack." These crackers are very tough. They measure about 5 inches square and a little more than an inch thick, and are pierced with thirty-six holes. From 93 to 96 kilograms of crackers are made from 100 kilograms of flour.

The milling is all done by grindstones, since by this method there is less waste than by cylinders.

The army bakeries use altogether each year from 70,000,000 to 80,000,000 kilograms of wheat, and their product is 82,500,000 kilograms, or 110,000,000 rations of bread, at 750 grams each, and 4,000,000 kilograms of "hard tack."

The navy department also has five or more bake shops at Cherbourg, Toulon, and other naval stations.

Bread for the inmates of all the hospitals of Paris, and for many of the public and private charitable institutions, is made in a great central bakery on Rue du Fer-à-Moulin. The wheat used is almost entirely of home production.

Pastry making in France may almost be called one of the fine arts. The display of pastry and biscuits at the Exposition was bewildering in its variety, including, as it did, the products of the best manufacturers of Paris and all France. The cities of Dijon and Rheims have long been famous for their gingerbreads. The square cakes of Lille and the hearts of Arras are well known. The gingerbread fair in Paris, lasting for a fortnight at Easter time, is one of the sights of the city. The origin of this fair is not known. Fifty years ago several hundred gingerbread merchants used to meet at what is now the Place de la Nation, in the lower part of Paris, to sell their products. In 1887 the hundreds of booths along the boulevards and in the squares covered 32,005 meters. Not only gingerbread, but all kinds of wares are now sold at this great fair. For fifteen days and fifteen nights there is great hilarity among the thousands of men, women, and children who crowd the vicinity to buy cakes, toss rings, ride the merry-go-rounds, and to enjoy an endless variety of cheap shows. From 9 o'clock in the evening till 1 or even 2 o'clock in the morning the excitement is at its height—all having a good time, as the French know how.

There are many kinds of French bread, distinguished by their composition, their form, their weight or volume, the use for which they are intended, or the particular names of the places where they are made, or the names of the persons who introduced them. The characteristic French loaf is long and narrow, sometimes a length of 3 or 4 feet. It is a common thing to see children carrying a loaf of bread as tall as themselves. There are the half length loaves, the split loaves, the round loaves, pointed loaves, crowned loaves, and many fancy shapes. Then there are the glazed loaves, the Vienna, German, and English breads, bread without crust or with crust, soup bread, coffee rolls, soft loaves, half soft, household bread, white and graham bread.

Some loaves of 4 pounds are sold by weight, among which are the short round loaves, the short split ones, thick round loaves, the half high and the flat loaves. Then there are fancy loaves of 4, 3, 2,

and 1 pounds which are divided into long and half long "jocko," plain and split "jocko." There are the crown loaves of the same weights, and even of half pounds. There are loaves which sell for 3 cents, 2 cents, and 1 cent, among which are the little "jocko" and Vienna rolls, and a score of other varieties, weighing from 9 to 3 ounces each. Then there are the small breads made of the finer grades of flour, called *pains de luxe*, of which there are twenty kinds in various shapes and prices from 1 to 3 cents apiece. Some kinds of small breads which are made with eggs, milk, and butter are sold as high as 15 cents a pound. Cheaper grades of bread are sold among the poor people, but very little bread of a second quality is made in the bake shops in Paris.

The cracker industry is more important in America than in the countries of Europe. Besides the crackers and biscuits made from unleavened dough, there is a great variety of fancy biscuits. The industry in France is confined chiefly to the making of wafers and army biscuit. England seems to take the lead in biscuit making. Several English machines for making crackers and wafers were exhibited. One of these was a sugar wafer machine, used by Huntley and Palmer and other great biscuit dealers. A description of this machine is given on a previous page in the discussion of bakers' ovens.

In the French section there was exhibited some bread made from soya, an oleagenous pea, native in China and Japan, where they make from it a kind of cheese. Soya bread is intended especially for dyspeptics. An analysis of this bread gives the following results:

Water	25.77
Gluten	34.36
Fats	1.36
Glucose	1.17
Amidon and dextrine	14.96
Mineral salts	2.79

THE COMPOSITION OF BREAD.

Bread is a mixture of flour and water in certain proportions. From this mixture results the dough made of a uniform consistence by kneading, an operation that may be performed either by hand or by a kneading machine. The batch of kneaded dough is left for a time to itself, then divided, weighed, put in form, and left again to rest. During the operation of kneading there is added some yeast, a leaven that causes fermentation, one of the most important steps in bread-making. Baking is the final operation, which also requires care.

Composition of breads of various kinds..

	Number of specimens.	Water.	Total nutrients.	Nutrients.			
				Protein.	Fats.	Carbohydrates.	Mineral matters.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Wheat bread	4	32.5	67.5	8.8	1.9	55.8	1.0
Graham bread (wheat)	1	34.2	65.8	9.5	1.4	53.3	1.6
Rye bread	1	30.0	70.0	8.4	0.5	59.7	1.4
Boston crackers	1	8.2	91.8	10.7	9.9	68.8	2.4
Soda crackers	1	8.0	92.0	10.3	9.4	70.5	1.8
Pilot (bread) crackers	1	7.9	92.1	12.4	4.4	74.2	1.1
Graham crackers	1	5.0	95.0	9.8	13.5	69.7	2.0
Oatmeal crackers	1	4.9	95.1	10.4	13.7	69.6	1.4
Oyster crackers	1	3.8	96.2	11.3	4.8	77.5	2.6

GRAHAM BREAD.

Graham flour contains the outer coverings of the wheat grain, which are separated as bran in the ordinary process of milling. The bran is rich in albuminoids and phosphates, and it was therefore inferred that Graham flour would prove more nutritious than white flour. It has been shown, however, that those constituents in the bran are not readily assimilated by the digestive organs, and that the nutritive value of Graham bread is not superior to that of ordinary bread although the bran may possibly be beneficial in mechanically stimulating the digestive organs.

In the action of the yeast on the dough the starch is partially converted into sugar, which undergoes fermentation, producing alcohol and carbonic acid gas. This gas in escaping lightens the dough. If the fermentation is continued too long acids will form, which makes the bread sour. In baking, the grains of starch absorb water and swell very much while some of the starch is changed into dextrine.

In a series of experiments it was found that 100 pounds of flour, 25 pounds of milk, 33 pounds of water, ½ pound of yeast, and 1¼ pounds of salt produced 135 pounds of bread with 90 pounds nutrients and 45 pounds water.

Bread has nearly the same composition as the flour from which it is made.

Composition of wheat bread.

	Per cent.
Water	32.7
Nutrients—	
Protein, gluten, etc	8.9
Fats, oily matters	1.9
Carbohydrates, starch	55.5
Mineral salts	1.0
	100.0

The cost of the nutrients in such bread, sold at 10 cents for a loaf of 18.7 ounces, is more than twice the cost of the same nutrients in the flour.

On an average the Paris bakers make 130 kilograms of bread from 100 kilograms of flour. This is the normal proportion, even for rye flour but sometimes they make 136 to 140 pounds of bread when the flour absorbs water well. In summer, water at ordinary temperature is best for making dough, but in winter it should be tepid, but never hot. The quantity of water needed varies according to the kind of flour, or of bread, and the temperature. In general, flours made from good, dry wheat preserve, after cooking, one third their weight of water, while some flours preserve only one-half or one-fifth. Some experiments made by M. Barral on the average consumption of Paris bread showed that the crust contained 15 to 20 per cent of water, and the crumb from 43 to 45 per cent, and that thirty-six to forty-one hundredths of the total weight of the loaf was water.

III.—METHODS OF THE BAKERY.

PREPARATION OF THE DOUGH.

Gluten, starch, and other insoluble materials in wheat represent from 72 to 75 per cent of its mass, while the soluble materials, as albumen and dextrine, represent only about 10 per cent. To render soluble in the stomach the greater part of the substances of the grain that are insoluble in water is the principal end to accomplish in bread-making. To make the starch soluble, so that it may be attacked by the gastric juice, it is moistened with water and the granules are split or burst by the heat in baking. The gluten also is more easily assimilated after being subjected to the kneading and fermentation.

In making the wheat bread so much used in Paris, the bakers depend for fermentation chiefly on dough left from the previous day's baking. About 8 o'clock in the evening they lay aside about 12 pounds of dough, and the next morning they knead it with an equal weight of fresh dough. About 2 o'clock in the afternoon they add 16 pounds of flour and 8 pounds of water, and at 5 o'clock 100 pounds of flour and 52 pounds of water and 0.2 to 0.3 of a pound of yeast are added, and again at 7 o'clock there is added 132 pounds of flour and 68 pounds of water, with 0.3 to 0.6 of a pound of yeast and 2 pounds of salt.

The baking is usually done in several batches, yielding bread of as many grades. The poorest bread is from the first baking, made from half the dough prepared as above. For the second batch, the baker takes half the dough left, kneads with it about 132 pounds of flour, 68 pounds of water, 0.3 to 0.6 of a pound of yeast, and 2 pounds

of salt. Only half of this is baked, and the remaining half is kneaded with more dough, as before, for a third batch; and the same operation is repeated for the fourth, and for the fifth or last batch, which makes the finest bread.

In describing the change of flour in becoming bread, Prof. Horsford says:

In popular use we employ the word "bread" to qualify loaves which are served in slices. The rolls are much smaller. Both alike consist of crumb and crust. The crumb is made up of a multitude of cells of thin walls, containing carbonic acid gas, the product of fermentation in the dough.

These walls of the cells contain both gluten and starch, and traces of dextrine and sugar. As a consequence of the treatment of water and the application of heat, the starch grains, which in their normal condition are little sacs filled with minute granules of starch proper, have been swollen and burst. The starch has undergone no especial change as the result of fermentation, beyond the conversion into glacial starch, and the conversion of a small amount into dextrine or gum sugar (glucose) and alcohol and carbonic acid gas. It has taken on a property which we observe in the boiled starch of the laundry, of drying in thin layers to a transparent, horn-like varnish, less readily taken up by water. The starch has also, in the mixing and kneading of the dough, become incorporated with the gluten, so that after baking, when it has become the glassy starch, it is no longer possible to separate the gluten as a distinct elastic body, such as may be produced from flour. *

Beer yeast and grain yeast have now very largely replaced the old-fashioned homemade yeasts. It is prepared in condition to keep for several days, or even weeks. In Holland the use of the so-called "compressed yeast" began, according to some authorities, as early as 1817. In Austria it was first used about 1847, and in the United States about 1868.

Press yeast is made by the maceration and fermentation of cereals that serve for distillation. The method of making Fleischman's compressed yeast, so extensively used in this country, is described in his patent, issued in 1870, as follows:

I mix corn and rye together, in the proportion of 70 parts corn to 30 of rye, adding thereto 4 parts rye malt and 2 of barley malt. To the above-named ingredients I add water at a temperature of 190° F., stirring the mass until it falls to a temperature of 150°, and ceases to precipitate a floury or creamy sediment. The mash is then covered, allowing it to remain under water for twenty-four hours, when it is again thoroughly stirred and brought to a temperature of 60° to 62° F., in the winter, or 41° to 46° in the summer, months. Brewer's yeast is then added (to start a fermentation), also crystallized soda and chloride of sodium.

The whole of the ingredients should now be thoroughly stirred, and the vessel which contains them closed with a cover having an aperture for the escape of the carbonic acid gas generated during the process of fermentation. The ingredients are left thus for 2 hours, or until the temperature is increased some 20° F., when a portion of the mash is separated and set aside, which forms mother-yeast to be used in the place of brewer's yeast employed in the first preparation of the mash. The

* International Exhibition, Vienna, 1873. Report on Vienna Bread, by E. N. Horsford, of the United States Scientific Commission.

mash should now be placed in a cylinder or tun, a vacant place of some 2 or 3 feet being left above its surface.

After a lapse of 4 hours, bubbles commence to form in large quantities, and, rising to the surface, coalesce, their aggregation constituting a heavy froth, which continues to collect for twelve hours, rising higher in the vacant portion of the tun as its volume increases. This froth must be removed when it has reached its maximum of quantity or formation, and immersed in cold water for six hours, when the water is drawn off, the yellow residuum being inclosed in a silk bag and strained (to free it from all husks and other extraneous matters) into a suitable vessel, where it is kept for twelve hours, after which more of the water is removed; and the substance is washed in this manner until the water taken from it ceases to flow off with a milky hue. The substance after being so treated, is inclosed in a cotton bag and submitted to hydraulic or other pressure, by which means any remaining moisture is thoroughly expressed, and the material thus prepared forms my compressed yeast.

In 1872 Mr. Fleischman patented an apparatus for separating the gluten and albumen or nitrogenized substance of the grain, constituting pure yeast, from the husks or other foreign substances contained in the froth or scum used in yeast manufacture.

Alden's granulated yeast, patented in 1863, is made in the following manner:

Take 100 pounds crushed barley malt and steep in 50 gallons water at a temperature of 140° or 150° F. for 1½ hours. Then draw off the liquor and add 30 gallons more water to the malt, which maintain at a temperature of 170° to 200° 1 hour. Then draw off, and, having added the last to the first liquor, with three-fourths of a pound of hops, boil the whole until the saccharometer indicates 10°. Then strain and the liquor is ready for use. To each gallon of the above liquor at the boiling temperature add 2½ pounds red-wheat flour, thoroughly mixing the latter until free of lumps, and when reduced by cooling to the temperature of 130°, add 1¼ pound of pea or bean flour for each gallon of the liquid. When further reduced by cooling to 85°, add to the mass fresh yeast in the proportion of one-half pint of the latter to 1 gallon of the mixture, and maintain the temperature at 85° for 48 hours. At this time the development of the yeast-plants will have been consummated, and the process should be immediately arrested. To accomplish this add to the yeast finely-ground white cornmeal or "millers' shorts" until the substance acquires the consistency of soft dough. The mass is then pressed through the meshes of a No. 6 wirecloth sieve, by which means the plastic substance is formed into numerous threads about one-eighth of an inch square, which fall and distribute themselves upon suitable frames below, which frames are immediately removed and placed in a position to expose the finely-divided substance or granules to a current of warm dry air. The moisture is thus very speedily evaporated from the yeast, and the fermenting process completely suspended.

It will be apparent that the yeast, when reduced to fine threads or granules, as stated, having a large amount of surface exposed to the warm dry air, is most rapidly and effectually deprived of moisture, and that no considerable amount of fermentation or change can take place from the time the first steps in the process of arresting fermentation are commenced until the yeast is dried and rendered secure. It will also appear that the yeast, when dried in this finely-divided or granulated state, is presented in the most convenient form for being subsequently dissolved for use, and that no injurious grinding or crushing process has been necessary to prepare it for use.

One of the best yeasts used by Baker & Son at the Exposition is a malt yeast, prepared by Lesalfe & Bondelle.

Hull's yeast cake, patented in 1889, has the yeast incorporated with prepared corn meal. It is made into rounded forms under great pressure, so as to force the finer granules of the corn meal to the surface, forming a thin, compact crust which serves to preserve the cake for a considerable time. An outer coating of sugary matter is added to insure its preservation.

Barnes's yeast cake, patented in 1889, is a sugar-coated cake, which, the inventor claims, will keep fresh for a long period.

They prepare in Vienna a leaven or "sponge" that will keep for a year, by boiling for twenty minutes a mixture of bran, flour, and hops. When the decoction ferments, they throw in a quantity of bran sufficient to make a very thick paste that they roll in pellets and dry with a mild heat.

Another dry yeast that will keep for a long time may be made by boiling 2 ounces of hops in water sufficient to make 3½ pints after filtering. There is then added 3½ pounds of rye meal, 6½ ounces of good yeast, and flour enough to make a thick paste, which is promptly dried in an oven.

Ludewig's yeast consists of 1 part of yeast and 4 parts of fresh water, to which is added a half ounce of pulverized carbonate of ammonia, *salvolatile*, for each pound of yeast. After decantation and straining the mixture is dried by pressure in sacks, and about a half ounce of sugar per pound of yeast is added. This yeast is very white and communicates no color or disagreeable taste to the bread.

Kirby's leaven, used in England, is made from boiled potatoes, sugar, or molasses, and ordinary beer yeast, and will keep in good condition for about three months.

The Danglish method of making aërated bread consists in charging the dough with carbonic dioxide, the operation being performed in a close vessel, under pressure. The aërated bread is rather tasteless, and its introduction in this country has not been very successful.

There has been an enormous increase during the last twenty years in the use of baking powders. A competent authority estimates that the annual consumption of these powders in the United States is between 50,000,000 and 75,000,000 pounds, two-thirds of which is made from cream of tartar, and the rest from phosphate and alum.*

I shall not here discuss the composition of these powders, nor the effect of alum as an ingredient of foods. In general it may be said that baking powders containing alum can not be viewed as harmless, and should be avoided if wholesome bread is desired.

The water employed to mix with the flour is somewhat warmed, and in fancy breads milk is used instead. The salt is added not only as a seasoning, but it supplies the hydrochloric acid and soda.

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*New York Tartar Company. U. S. Department of Agriculture, Division of Chmeistry, Bulletin No. 13, part 5, Baking Powders.

KNEADING MACHINES.

Kneading machines have very generally replaced hand work in all well-equipped bakeries in this country and Europe. The dough and yeast are more evenly mixed, and the bread has a handsome appearance. Many designs of kneading machines were exhibited in the French and English sections, some of which I will briefly describe.

The Dathis kneading machine (Pl. XXXI, Fig. 1) was shown at the Exposition, and at the model bakery on the Avenue de l'Opera. It is claimed by the manufacturers that this machine produces a superior dough. The kneading forks have a motion much like hand work.

The Deliry kneader (Pl. XXI, Fig. 2) is operated either by hand or steam power. The pan revolves in the opposite direction to the movement of the kneading arms. This machine is much used in the civil and military bakeries of France.

A kneading machine in very general use is that known as the Boland patent (Pl. XXXII). It is convenient to work and does perfect kneading. They are used in many of the Government establishments, and in large bakeries and starch factories in France, Belgium, and Holland, and are also common in Great Britain and the United States.

The method of working these machines is as follows:

For sponge doughs put the necessary quantity of flour into the kneader, and pour water from above heated to the proper temperature and containing the diluted leaven; set the machine in motion, and let it run about 50 revolutions at a speed of only 6 revolutions per minute. This completes the first mixing, when flour is added to make the dough of the required consistency. Then the kneading proper commences, the blades of the screw, by their correct mathematical disposition, the helicoidal pallets of which exercise an effectual influence on the dough, developing it in successive sheets, drawing it out lengthwise from front to back, from left to right, and *vice versa*, puffing it up by introducing the necessary air, and, in a word, forming a dough more complete than could be made by the hands of the strongest workman.

To mix and knead cornhill and similar doughs the sugar and lard, or butter, are put into the kneader and worked thoroughly together, after which the flour and liquor are added and the mixing completed. In mixing all stiff doughs a uniform speed of 6 revolutions per minute of the blade will be found sufficient. On soft doughs the speed may be somewhat faster if desired.

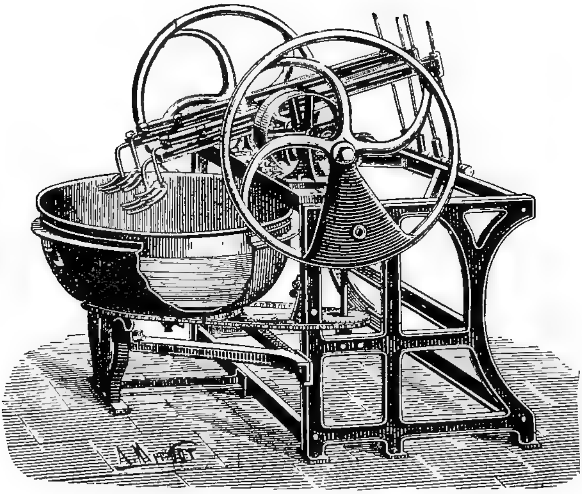
Some of the advantages of using the Boland kneader in the manufacture of loaf bread are:

(1) The quality of the bread is uniform, the dough is well worked, no lumps forming in it.

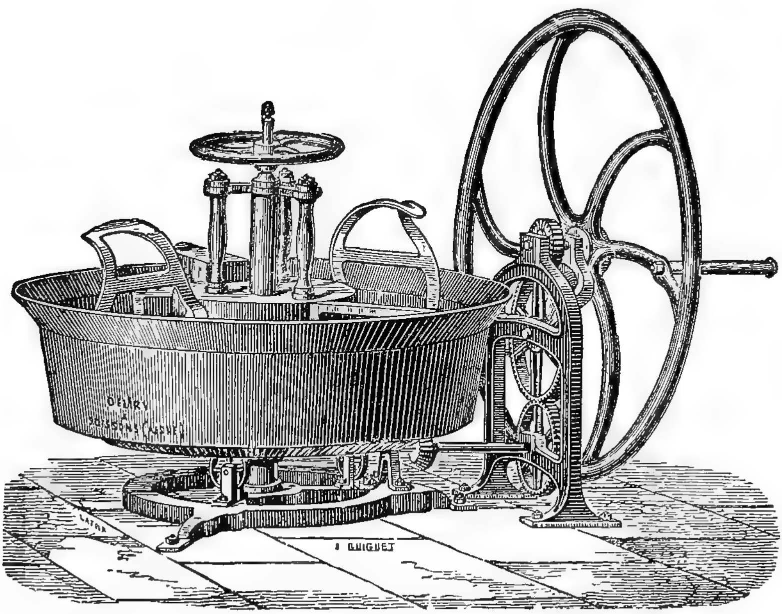
(2) The yield of a given quantity of flour is always the same, which is not the case when kneaded by hand.

(3) The kneading is done rapidly, so that the dough is not liable to get dry from contact with the air before it is sufficiently worked.

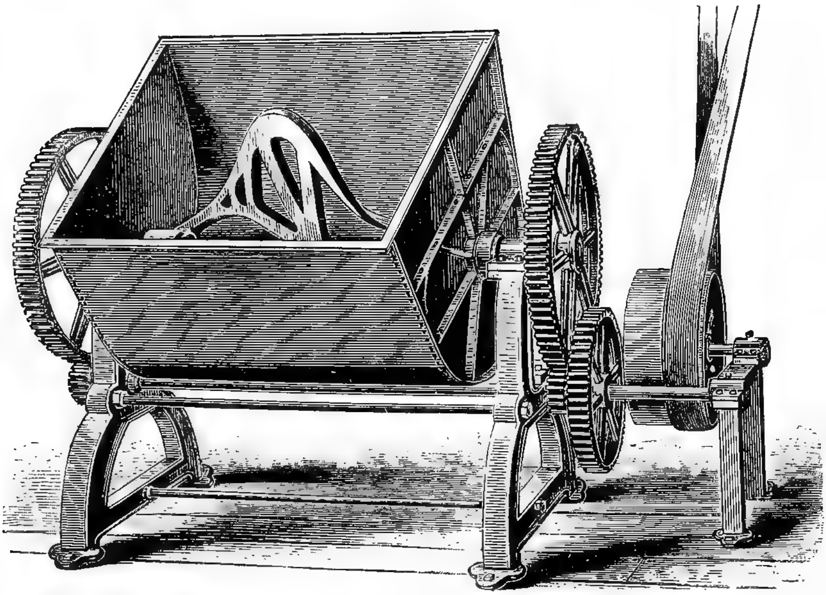
(4) The dough is kneaded to any degree of firmness required, and with great precision.



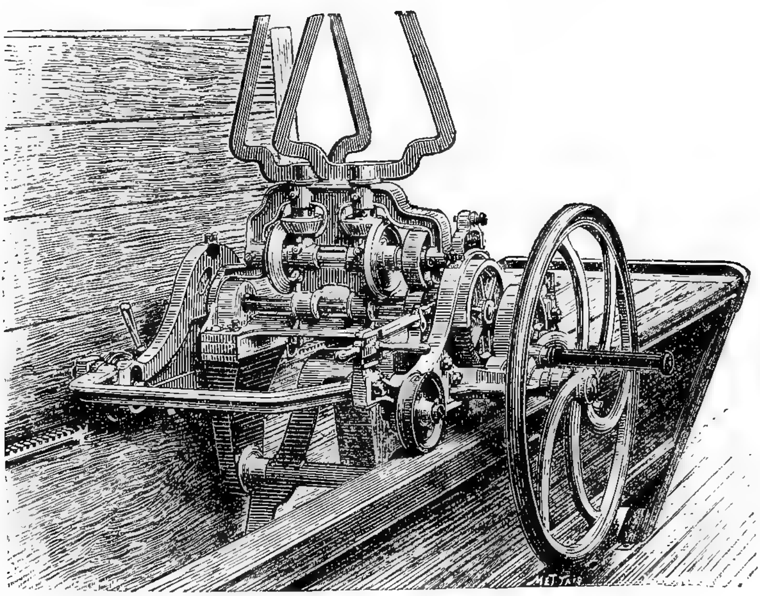
1. DATHIS KNEADING MACHINE.



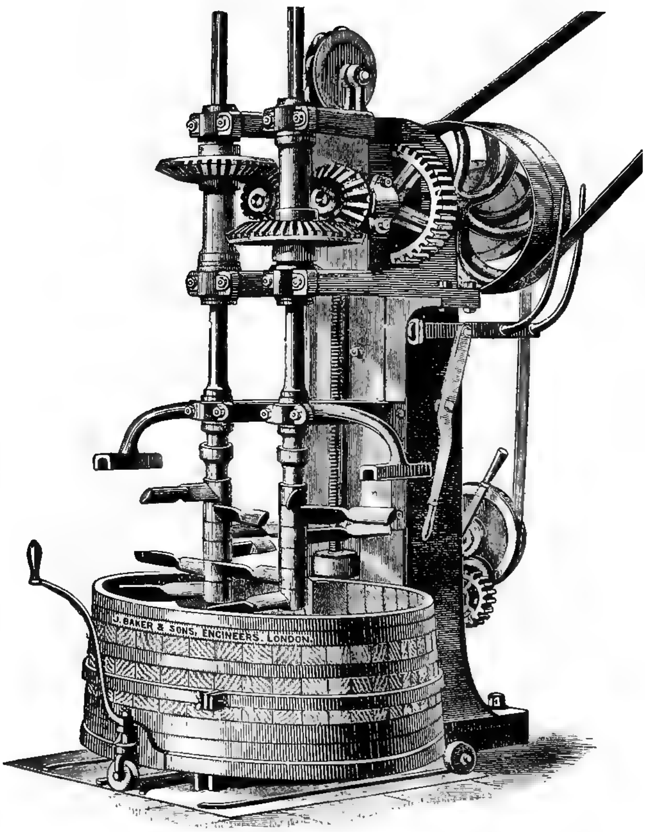
2. DELIRY KNEADING MACHINE.



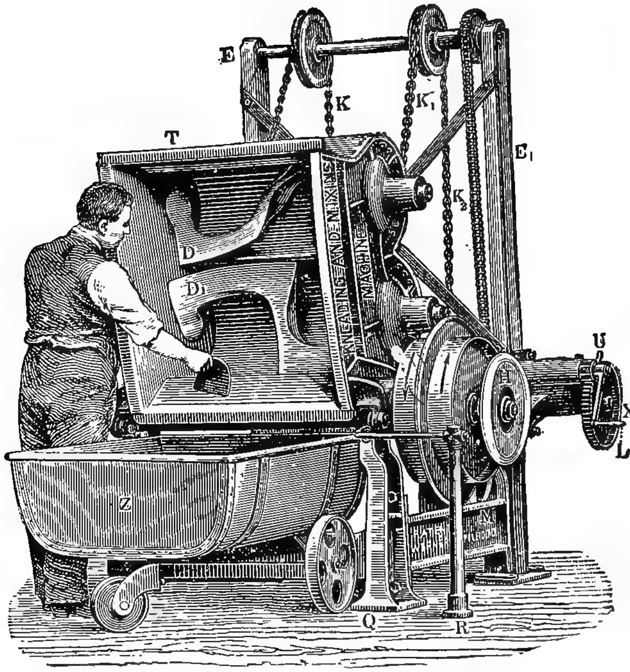
1. BOLAND KNEADER.



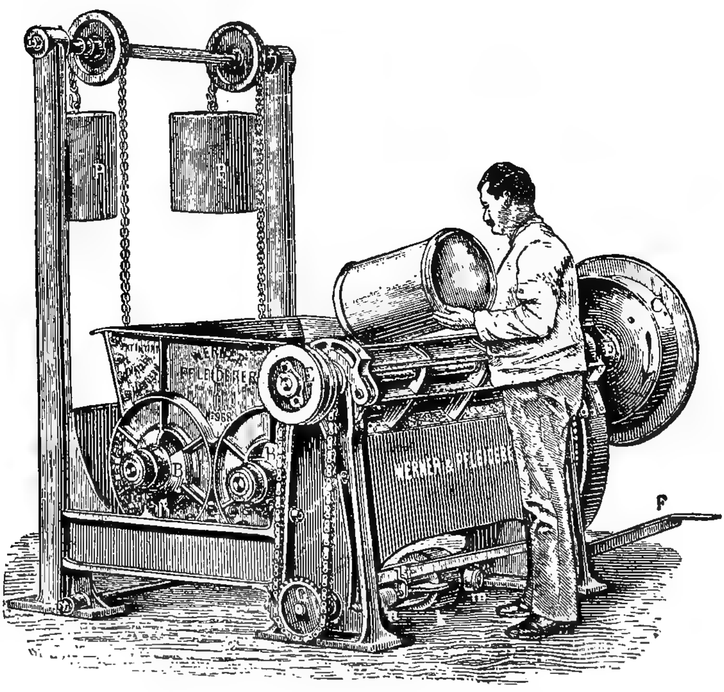
2. DAGRY KNEADING MACHINE.



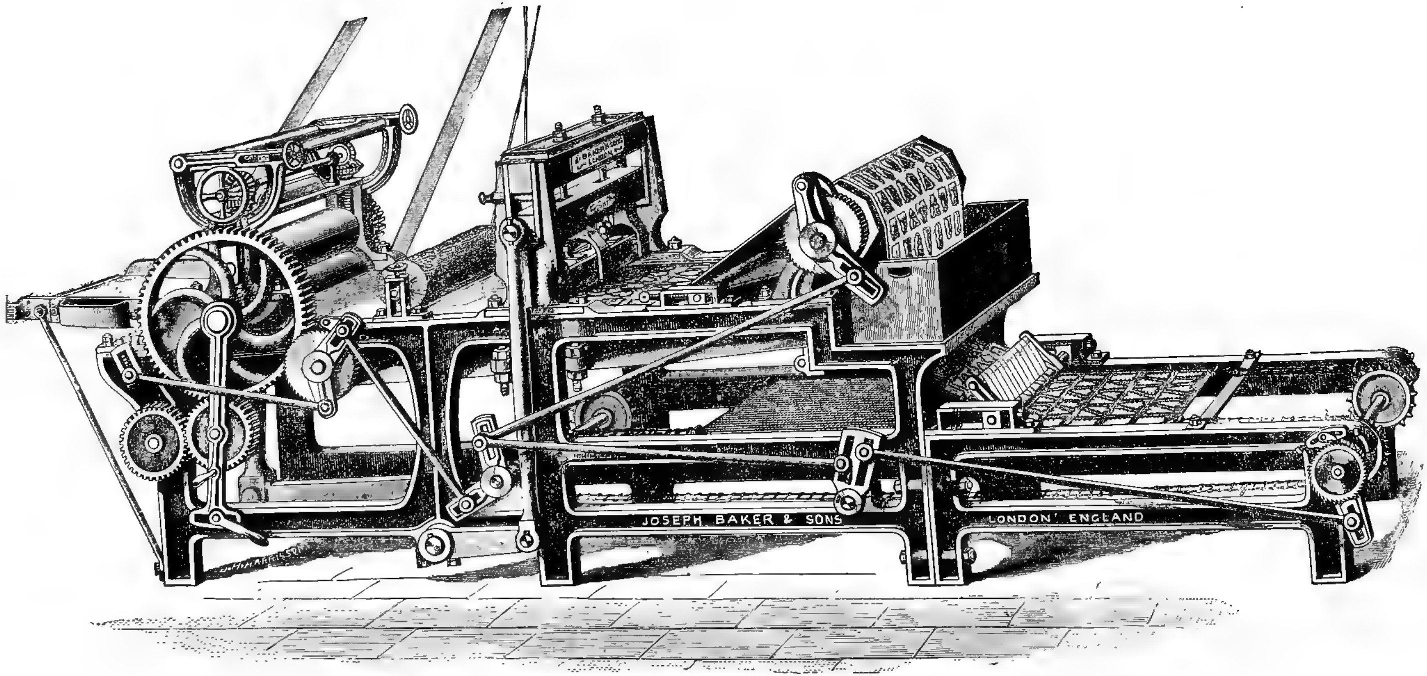
BAKER'S VERTICAL MIXING MACHINE.



1. UNIVERSAL KNEADING MACHINE TILTED, EMPTYING.



2. UNIVERSAL KNEADING MACHINE IN WORKING POSITION.



BAKER'S BISCUIT CUTTING GAUGING AND PANNING MACHINE.

(5) The service is regular and may be assured continuously, which is a convenience and a satisfaction.

Finally, they effect an immense saving of labor. The No. 1 machine, capable of kneading from 1 to 6 barrels of flour at a mixing, does the work of 16 men.

Baker's vertical kneading machine (Plate XXXIII), was in daily operation in the English section of the Exposition. It is a powerful machine, well adapted for soft, rich biscuit doughs, or for mixing or kneading. The mixers or kneading arms are so constructed that they are automatically lowered into the tubs or troughs, and are raised when the work is completed. There is therefore, no winding up or raising of the tubs to the mixers.. The tubs, which stand firmly upon the floor, are very strongly made, and are fitted upon wheels, so that one tub can take the place of another as soon as the mixing is done. The mixers are driven by powerful bevel gearing, and are raised and lowered by friction gear arranged so that the mixers raise or lower automatically only the distance required, and without throwing the rest of the machine out of gear. This heavy pillar form of machine is convenient and occupies little space. For bread-making special kneading arms are constructed and fixed to the spindles instead of the mixers as shown in the illustration.

A kneading machine to be attached to the mixing trough and arranged with a combination, reversible movement, was exhibited by M. Dagry, of Paris (Pl. XXXII, Fig. 2).

The "Universal" kneading machine, made by Werner & Pfleiderer, of London, is much used by English bakers. It is made in various sizes. As compared with the Boland kneader it appears rather clumsy. Two drawings of the machine are shown, one tilted for emptying, and the other in working position. (Plate XXXIV.)

CRACKER-CUTTING MACHINE.

Biscuit or cracker cutting is now universally done by machinery. Several excellent machines were shown at the Exposition. I give an illustration of the machine exhibited by Joseph Baker & Sons, of London (Pl. XXXV). The makers describe the machine as follows:

This new-design machine combines the most recent improvements in a very compact form, and includes, at a very moderate price, such special advantages and improvements as were hitherto only represented in the larger machines of No. 3 size. In this No. 2¼ machine we have applied all these improvements, so that it gives in a very compact form the best medium-size cutting machine which has ever been made. As in the other machines, the gauge rollers give to the dough the desired thickness, after which by means of an endless web it is carried forward under the revolving brush, or if preferred under a revolving fan. For making certain kinds of biscuits the crimp roller takes the place of the revolving brush. This crimps the biscuits on top before they pass onwards to the cutters. The separating of the "scrap" from the biscuits is then performed by a separating web and roller, while the biscuits are carried forward and automatically deposited upon the pans or wires. In this operation, by means of the new skip motion, every biscuit is deposited regularly upon the pans, and when one pan or wire is filled it is

hitched forward so that the succeeding biscuits are placed on the next wire or pan without any of the biscuits being deposited on the edges of the two pans, or between them, as was the case before the invention of the "skip motion." By this improvement one less attendant is required.

A continuous motion is given to the gauge rolls by means of the "change wheels," and a new spring adjustment fitted under the bearing of the top roller takes up the wear. By the adoption of these improvements all creasing of the dough is prevented, and perfect and regular working is assured. This is a great advantage over the irregular motion of the ratchet wheels of the old-style machines.

The machine is driven by a three-speed pulley, for giving different speeds for making the various sizes of biscuits, or can be driven by the special cone gearing as preferred. This size machine is suitable for working in connection with a small traveling or reel oven, or the Bailey-Baker Continuous Ovens, and is adapted for manufacturing all kinds of hard and soft dough, fancy biscuits, and block goods, as Walnuts, Floral, Balmoral, etc.

BAKERS' OVENS.

Round loaves are seldom made in Paris, except with Graham flour. The bakers have adopted the long loaves, which are more convenient to handle, bake better, and have more crust.

After the loaves of dough are shaped, flour or some fine bran is sifted over them and they are covered with linen cloths and left for a time to rise in shallow baskets.

According to the mode of heating them, ovens may be divided into five classes: (1) Those heated by wood burnt on the hearth of the oven; (2) Those heated by the direct passage of heat from a wood or a coal fire beneath the oven; (3) those heated by hot air chambers outside the oven without the direct passage of the heat in the oven; (4) those heated by the introduction of heated air; (5) those heated by steam and by hot water or by gas.

I shall not attempt to discuss here all the above classes of ovens. Each is adapted to certain classes of work, or at least preferred by certain bakers. Several improvements in ovens were shown at the Exposition, some of them in operation in baking bread-wafers, and crackers. The ovens exhibited by the manufacturers of Olivet biscuits, and those for baking wafers and cakes, exhibited by Joseph Baker & Sons, worked perfectly.

A very primitive oven is that used by the Indians of Arizona, as also probably by aborigines in other regions. In making corn bread they pour the corn meal, mixed with water, upon a hot stone. It comes off in thin sheets, a number of which are folded together, and is an excellent bread. Sometimes dough is simply dried in the sun or is baked in hot sand.

The Lamoureux oven, shown at the Exposition, is much used in France in the Government bakeries as well as in private establishments. It is of the direct-heat class of ovens, and adapted to the use of wood, coke, or coal. The heat may be admitted from above through the arch, or from below through the sole or hearth. I give

below the construction of the ovens (Pls. XXXVI–XXXVIII) as described in the United States patent (No. 347181, August 10, 1886).

The invention consists, essentially, in the combination, with a baker's oven, of means whereby the said oven may be heated either by means of wood, in the usual manner, or by means of coal, coke, or other carbonaceous material, and more especially, first, in the arrangement of heating flues and theirc ombination with a furnace, the oven, and the chimney, whereby the oven may be heated by the heat derived from an incandescent carbonaceous material and admitted to the oven either at the sole or at the arch thereof; second, in the combination of means whereby the heat and products of combustion of the carbonaceous material may be conducted through the oven from below or from above, or directly to the chimney, or in part through the oven and thence to the chimney, and in part directly from the furnace to the chimney; third, in the combination of an air or ventilating flue or flues with the furnace, to practically isolate the latter from the body of the masonry and form a cooling chamber to preserve the masonry of the furnace.

In the accompanying drawings, Fig. 6 shows in elevation an ordinary baker's oven with improvements applied. Fig. 7 is a longitudinal vertical section thereof. Fig. 8 is a horizontal transverse section of the oven, taken on a line above the sole of the oven and showing the mouth of the heating flue for heating the oven from below. Fig. 9 is a horizontal transverse section showing the heating flue, the draft flue to the chimney, and the air flue. Fig. 10 is a vertical section of the oven, taken on the line 1 1 of Fig. 8. Fig. 11 is a like view taken on line 2, 3, 4 of Fig. 3, showing the arrangement of heating flue for heating the oven from below, and in dotted lines the flue for heating the same from above, said figures also showing the grate and draft flue and the connection of the latter with the chimney; and Fig. 7 is a section on line 5, 6, 7 of Fig. 7.

In the above drawings, M indicates the masonry; O, the oven; S, the sole, and A the arch thereof, and D the door that closes the mouth of the oven. The oven is connected by flues F F′ with the chimney C, said flue being provided with dampers *d d*, Fig. 2.

It will be observed that the arrangement of the parts so far described are those of an ordinary bake oven adapted to be heated by means of wood thrown into it, the products of combustion passing from the rear end thereof, through flues *f f′* and the return flues F F′, to the draft flue F^2 above the oven door that communicates with the chimney C.

To adapt the oven to be heated with coal or other carbonaceous material, either from top or below, according to my invention, I have made the following provisions: Immediately behind the oven door is an opening, *o*, formed in the sole S of the oven, provided with a grate, G, the bars of which I preferably make conical in cross section, either from top downward or inversely, or give them any other form, by means of which the heat entering the oven is divided and deflected at an angle to its natural vertical line of flow, as more plainly shown in Fig. 7. The opening *o* is the terminal of a heating flue, H, that communicates with the furnace I on the right and below the oven door, from which furnace the heat and products of combustion pass through flue H and grate G to the oven O, thence by flues *f* and *f′* and return flues F and F′, respectfully, to draft flue F^2 and chimney C. A draft flue, K, Figs. 4 and 6, connects the furnace I directly with the chimney C, and said flue has a damper, *k*, to cut off said connection when desired. A plate, P, of metal or refractory material, is placed over the opening *o* after the oven is heated, to cut the latter off from the source of heat, and direct communication between the said furnace and the draft flue F^2 and chimney C may then be established by opening the damper *k*, and allowing the heat and products of combustion to pass directly from the furnace through flue K to the draft flue F^2 and chimney C. As more plainly shown in Fig. 7, a second heating flue, L, provided with a damper, *l*, rises

directly from dampers *d d*, and opening *o*, as well as the damper in flue L, are closed, and the damper *k* of draft flue K is opened and remains open until the fuel on grate I is in an incandescent condition. The damper *k* of flue K is now closed and the damper of the heating flue L opened, admitting the heat from the furnace I to the oven at the arch. If it is desired to heat the oven from below, the flue L is closed and the opening *o* uncovered, the heat from the furnace I being now admitted to the oven at the sole through the heating flue H.

The oven may be divided into two or more chambers by means of removable partitions *p*, Fig. 5, each chamber being in communication with a return flue, F or F'. by means of a flue, *f* or *f'* and by adjusting the covering plate P, that covers the opening *o*, or the damper in the flue L, one of the said chambers may be heated to a higher degree than the other, and under ordinary circumstances the said partition also serves to more equally distribute the heat.

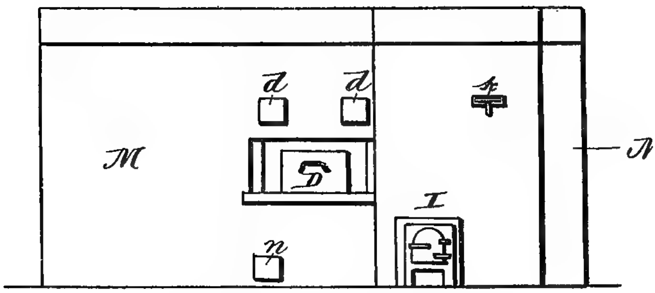
It will be observed that by means of the described arrangement of furnace draft and heating flues the products of combustion, when the oven is heated by means of coal or other similar carbonaceous material, do not pass through the oven to the chimney; consequently the carbonic-acid gases and other products of combustion have no unpleasant or deleterious effect upon the material baked.

One of the most interesting bakers' machines shown at the Exposition was used in the manufacture of sugar-wafer cakes. It was invented in 1865 by Mr. George S. Baker, of London, and was operated daily in the English section. The principal feature of the machine is an endless chain of baking pans, which are opened and closed automatically by a very ingenious device. The baking is by gas, and requires little time and labor.

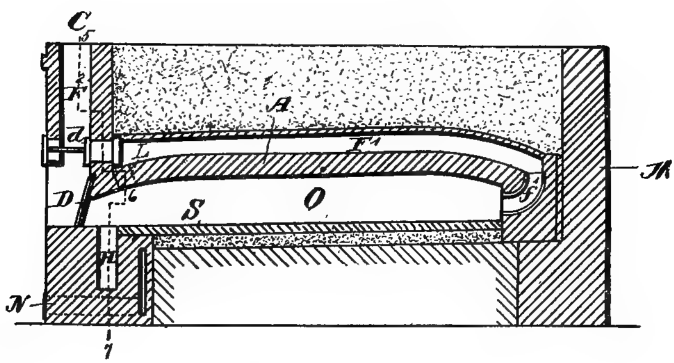
The sugar-wafer machine may be operated by one man or a man and a boy. The plates open automatically for the removal of the baked sheet of wafers, and are closed in like manner when freshly charged with the quantity of batter required for the following wafer sheet. Each pair of plates are self-baking, and thus holding the batter between them they pass through and make the circuit of the baking-chamber, being heated in their passage by the atmospheric gas stoves, which are suitably arranged to give a perfectly equal heat on both top and bottom plates. The baking is completed during the circuit, and the plates as they come around to the operator are automatically unlocked and opened, delivering the baked wafer sheet to the operator, who recharges them with batter. There are twelve plates in a full-size machine, each plate being the size for thirty ordinary sugar wafers. The time required for baking is four or five minutes.

The construction of the machine I give in full, with drawings from the United States patent (No. 353837), December 7, 1886 (Pl. XXXIX–XLI):

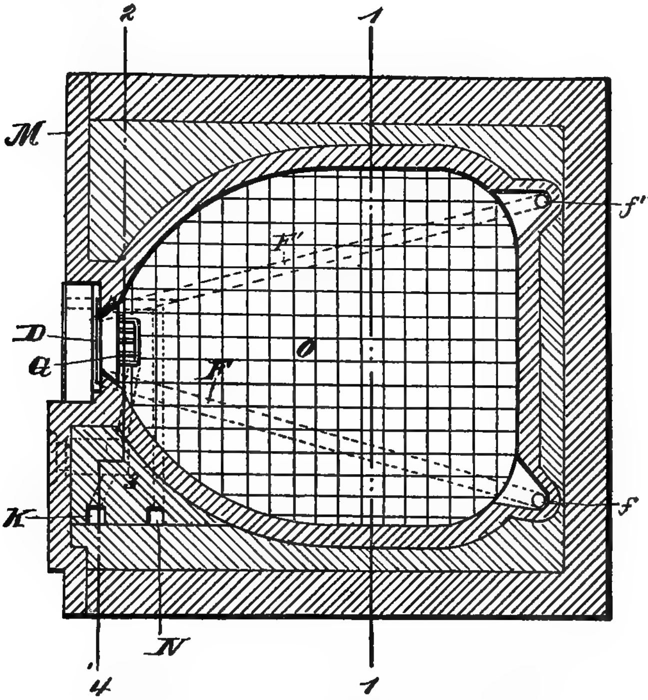
Plate XXXIX shows the improved machine by a side elevation, the inclosing case and part of the frame work being removed to show the operating devices thereof. Pl. XL, Fig. 1, is a top plan view with the greater part of the inclosing case removed. Pl. XL, Figs. 2, 3, 4, illustrate the driving mechanism for the forms or baking pans. Pl. XLI, Fig. 1, is a detached detail view of a portion of the endless baking forms



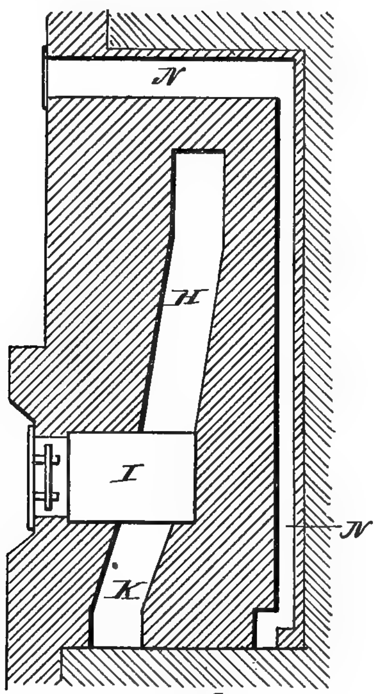
6. LAMOUREUX OVEN FRONT VIEW.



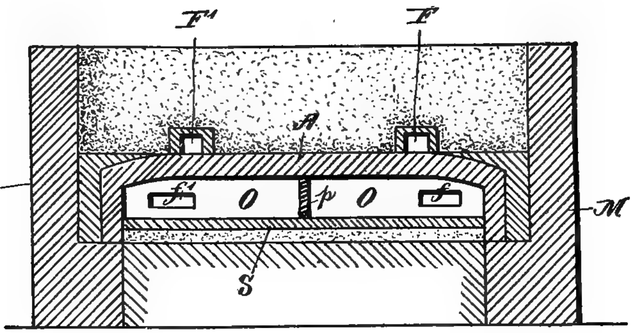
7. LAMOUREUX OVEN SECTIONAL VIEW.



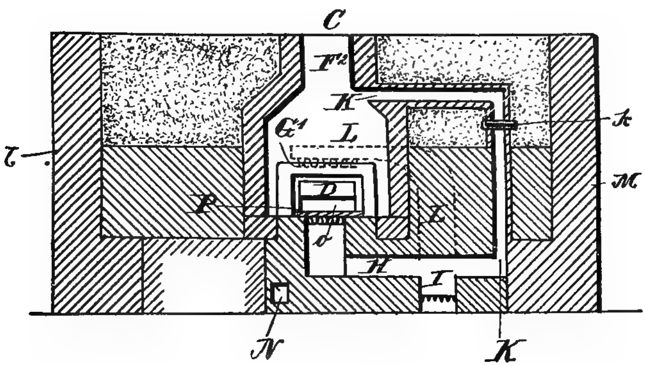
8. LAMOUREUX OVEN, HORIZONTAL TRANSVERSE SECTION.



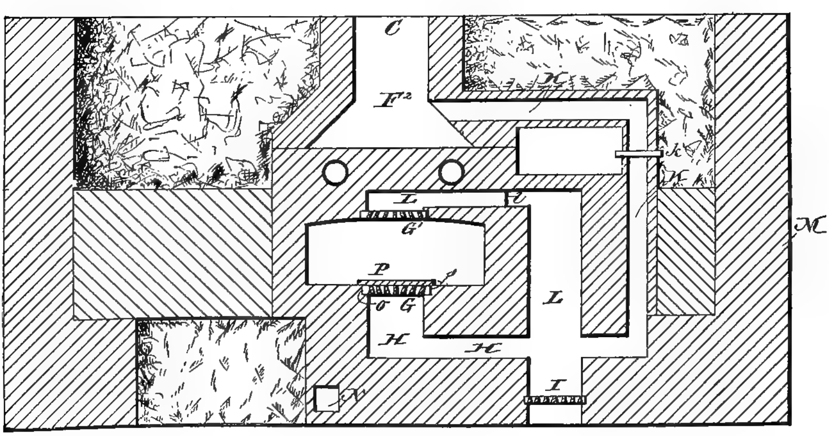
9. LAMOUREUX OVEN, HORIZONTAL SECTION.



10. LAMOUREUX OVEN, VERTICAL SECTION.



11. LAMOUREUX OVEN, VERTICAL SECTION.



12. LAMOUREUX OVEN, SECTION.

or frames and the driving shaft and wheel therefor, one of the guide rails only being shown. Pl. XLI, Fig. 1, is a top plan view of one of the baking pans or forms and a portion of the track, showing the lug or stop E^3 that rotates the locking bolt of the pan lids to unlock the latter. Pl. XLI, Fig. 3, is a side elevation of one of the baking forms or frames and one of the guide rails. Pl. XLI, Fig. 4, is an end view of one of the baking forms or frames with the lid or cover thrown open; and Pl. XLI, Fig. 5, is a detail view showing a portion of one of the guide and carrier rails and the stud or lug E^2 that engages the starwheel of the locking bolts for the pan lids to lock the latter.

This invention has for its object to provide a machine for baking sugar wafers and the like, which shall be as nearly as possible automatic in all its operations, and therefore, require but little attention, and will for yielding its full effect require but two attendants, although but a single one would suffice to work the machine at a slower rate.

The invention consists in certain novel features of construction, substantially as hereinafter fully described, and as set forth in the claims.

In the drawings, A indicates the main framing of the machine, which is inclosed in a double-walled jacket or inclosing casing N provided with a filling of any suitable material that is a nonconductor of heat.

B B indicate the baking pans or forms, or irons. (More plainly shown in Pl. XLI, Figs. 1, 2, 4, the lid of the pan in the latter figure being shown as thrown open.) These pans or irons consist of the pan proper B′ fitted on two crossbars b that have vertical lugs b', to which is hinged the lid or cover B^2. From the center of the lid projects a strap b^2 that has a slot b^3, and at the end of said strap is formed a stud b^4, for purposes presently described.

In a boss or bracket projecting from the pan B is pivotally secured a vertical locking bolt B^3 that has a T head, b^x, adapted to pass through the slot b^3 of the locking strap b^2 when said bolt is in proper position, so that the head thereof will register with said slot. At its lower end the locking bolt or pin B^3 carries a star wheel B^4, by means of which and mechanism presently to be described the bolt is actuated to lock or unlock the lid B^2 to or from the pan B′. The crossbars b have trunnions for the carrying wheels B^5.

The pans constructed as described are connected in an endless series by means of links B^6 that connect the rear and front trunnions respectively of two successive pans, as more plainly shown in Pl. XLI. Fig. 1, the said links forming an endless chain with the pans.

From the under side of the rear cross bar b projects a lug, or shoulder b^5, Pl. Pl. XLI, Figs. 1, 4, upon which impinges the teeth of two sprocket or pitch wheels F one for each side of the chain of pans B.

E and E′ are guide rails or tracks upon which the pans travel, and by which they are guided. The guide rails E extend along the frame and its ends and form endless tracks, while the guide rails E′ extend only the length of the frame A at the bottom thereof, and partially around its curved ends, so that when the pans travel along the lower part of the machine they are guided by two rails or tracks—one above the other—below the wheels B^5.

If desired. the wheels B^5 on the pan-carriage may be dispensed with and friction rolls secured to the tracks, and the same result obtained.

The pitch wheels F for propelling the chain of pans along the tracks E E′ are mounted on a shaft F that has its bearings in the framing of the machine, and carries at its outer end, outside of the inclosing jacket or case N, a gear wheel G′ that meshes with a like wheel G′ on the outer end of a shaft H. The latter shaft carries a ratchet gearing, by means of which an intermitting movement is imparted to the shaft F′, and through the latter to the chain of pans, the said shaft H being driven from the main driving shaft I at one end of the machine through the ratchet gearing, which is of novel and peculiar construction.

H′ and H^2 are two eccentric-rods, driven respectively by eccentrics H^3 H^4 on the main driving shaft I, which also carries the usual belt pulleys J J′. The eccentric rod H′, which is driven by the smaller eccentric H^3, is connected to a slotted arm h' that is pivoted or loosely mounted on shaft H, the amplitude of the throw of said rod H′ being adjusted by means of the slots h^x, Figs. 1 and 3.

Upon the arm h' is pivoted a pawl h^3 which engages with the teeth of a rachet wheel O, which is loosely mounted on shaft H, and imparts to said rachet wheel a slow step-by-step rotation.

From one face of the ratchet wheel O projects a collar O′, within which is arranged a ratche -wheel P that has a considerably less number of teeth than the ratchet wheel O, and in said collar is formed a hiatus *o*.

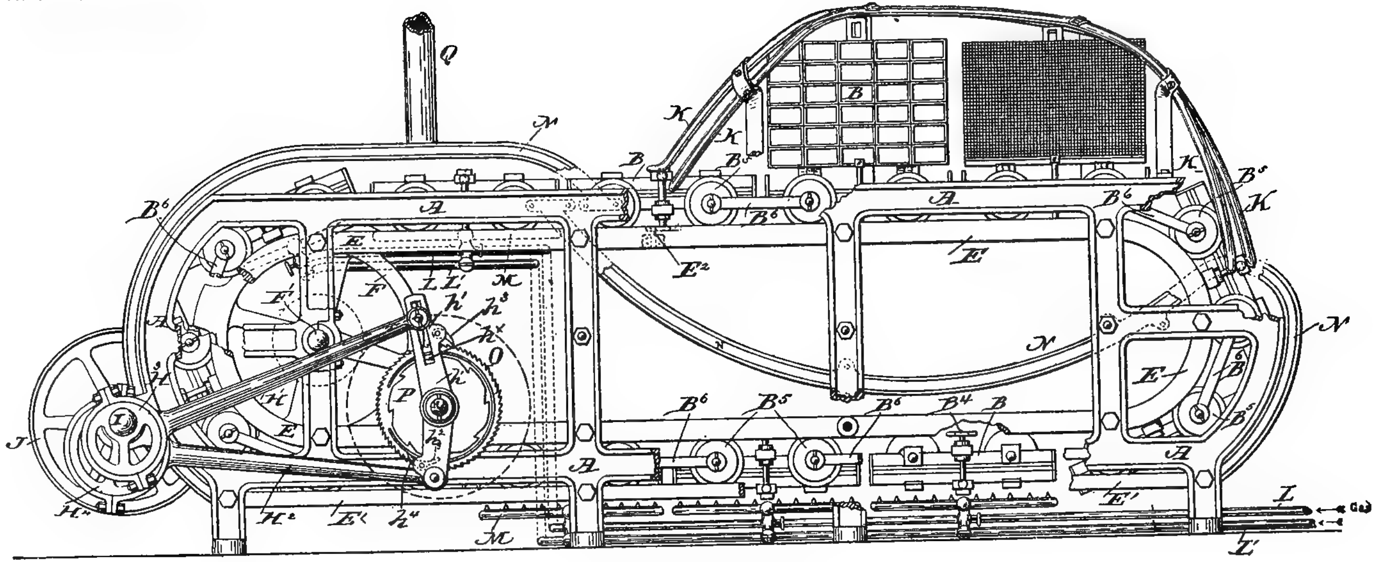
Upon shaft H is loosely mounted a second arm h^2 that is operated from the eccentric rod H^2 and larger eccentric H^4. Upon the said arm h^2 is pivoted a spring-actuated pawl h^4 that rides upon the collar O′ until it reaches the hiatus *o* therein, when said pawl, under the stress of its spring, drops into engagement with the teeth of the ratchet wheel P, rigidly secured to shaft H, and carries said ratchet wheel around with it. As the ratchet wheel O continues its rotation, the pawl h^4 is again disengaged from the teeth of the ratchet wheel P, and rides on collar O″ until it has traveled around to bring the hiatus *o* thereof in position to allow the pawl h^4 to again drop into engagement with the rachet wheel P.

The throw of the eccentric rod H^2, as stated above, is greater than that of the rod H′, so as to impart a sufficient turn to the ratchet wheel P. However, the proportionate sizes of the eccentrics may be varied to suit the circumstances. It will thus be seen that the ratchet wheel P drives the shaft H intermittingly, and the intermittent rotation of the latter is communicated to the shaft F′ through the gearing G′ G, and through shaft F′ an intermitting movement is imparted to the chain of pans B.

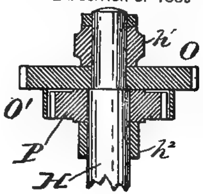
The relative arrangement of the ratchets O P and their operating mechanism is such that the intermission in the movement of the pans occur at a time when the lids of said pans are thrown open, and the duration of this intermission in the movement of the chain of pans is such as to allow time for the open pans to be emptied and refilled before they pass on and are closed np again. This method of driving is preferred for general purposes; but it is sometimes desirable to have a slow continuous movement of the forms, and in such case the ratchet movement is dispensed with and any suitable form of slow-driving mechanism adopted, such as ordinary spur gearing moving slowly.

The operation of unlocking the pan lids of throwing said lids open, of reclosing and locking the same to the pans, is effected automatically by the following instrumentalities:

K K are guide rails, forming between them a narrow guide-slot, said rails or bars extending from the rear end of the machine over its top, from one side of the frame toward the other and back again. At the initial or rear end of the guide track K K the rails are slightly spread and lie in the path of the lugs b^4, that project from the end of the locking straps b^2 of the pan lids B^2. From the rail E projects a tooth or lug, E^3, the said tooth lying in the path of the star wheels B^4 on the locking bolts B^3 of the pan carriages. This tooth or lug E^3 is located at the initial or rear end of the guide slot formed by the rails K K, and as the lug b^4 on the lid strap b^2 enters into the slot between said rails K K the tooth E^3 engages the teeth on the star wheel B^4 and imparts to the locking bolt B^3 one-half of a revolution. This movement of the bolt places the T-head b^x thereof on a line with the slot b^3 of the lid strap, and as the pans continue their movement the lug b^2 on the lid strap being guided by the slot between the rails K K, said lid is gradually thrown open, The arrangement of the rails K K is such that the lids of two pans will be open simultaneously—one attendant emptying a pan and the other filling it—the movement of the chain of



SUGAR-WAFER MACHINE.



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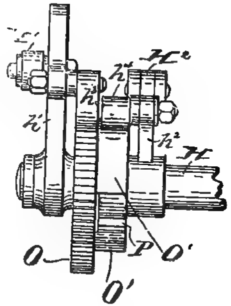

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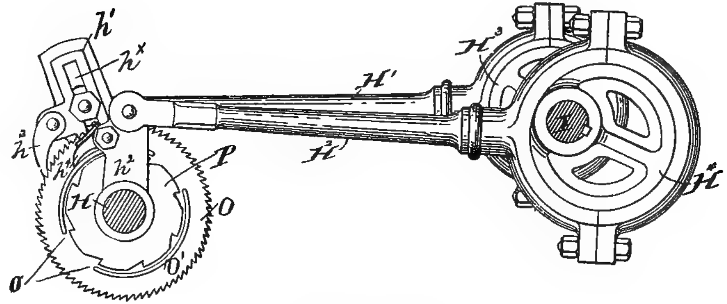
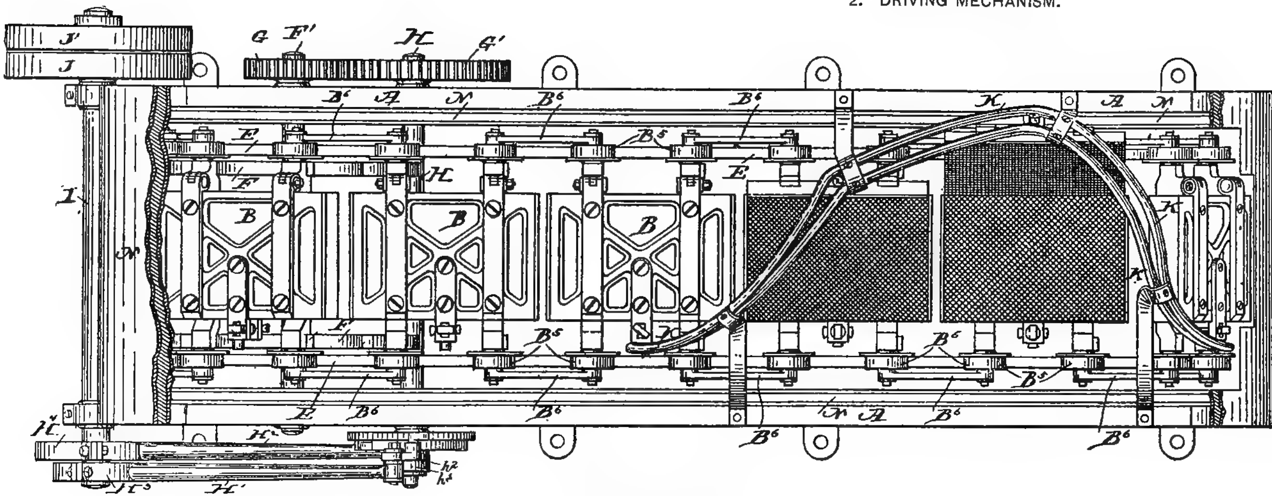
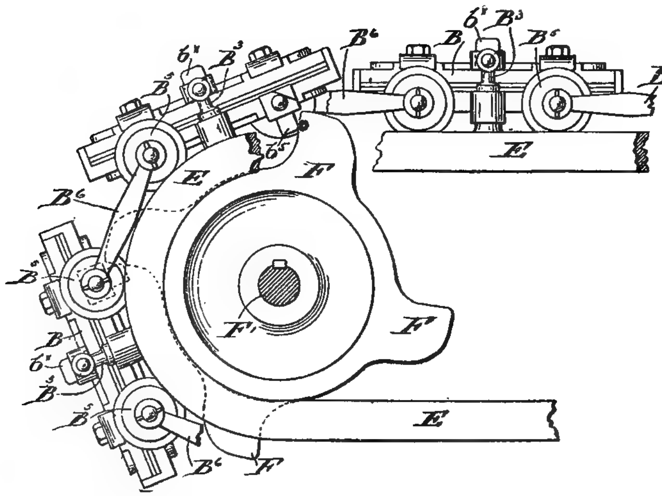


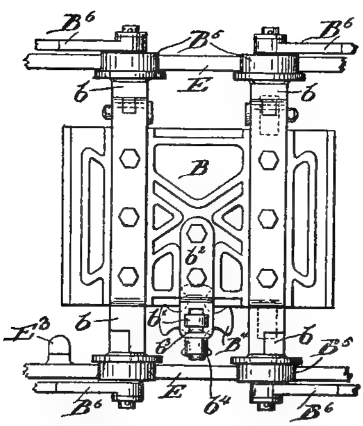
2. DRIVING MECHANISM.



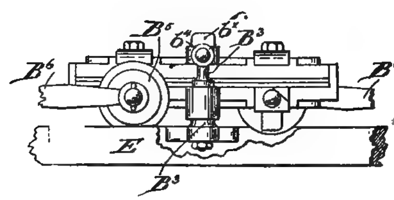
1. SUGAR-WAFER MACHINE.



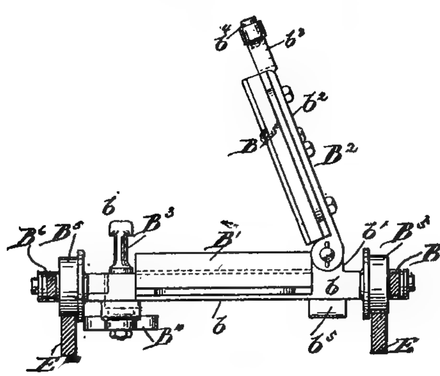
1. DETAILED VIEW OF BAKING FORMS.



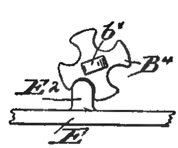
2. TOP PLAN OF BAKING PAN AND TRACK.



3. SIDE ELEVATION OF BAKING FORM.



4. END VIEW OF BAKING FORM.



5. GUIDE AND CARRIER RAIL.

pans being arrested a sufficiently long time to effect this, as above described. As the baking pans travel along the track E toward the front of the machine the lids B^2 thereof are closed, and as the lug b^4 of the locking-strap b^2 of said lids leave the guide slot between the rails K K a second lug E^2, that projects from the track E, again engages the teeth of the star wheel B^4 and imparts to it one-half a revolution, whereby the locking bolt B^3 is rotated to bring the T or cross head b^x thereof across the upper face of the slot b^3 in the locking strap of the lid B^2 and lock the latter securely in position. In this manner the pans as they successively pass along the guides K K have their lids automatically opened and closed again, thereby saving a great deal of labor and time.

The machine is supplied with the necessary heat by the following instrumentalities:

L and L′ are tubes which conduct gas and air to the burners M, and Q is the pipe through which the gases and products of combustion are exhausted.

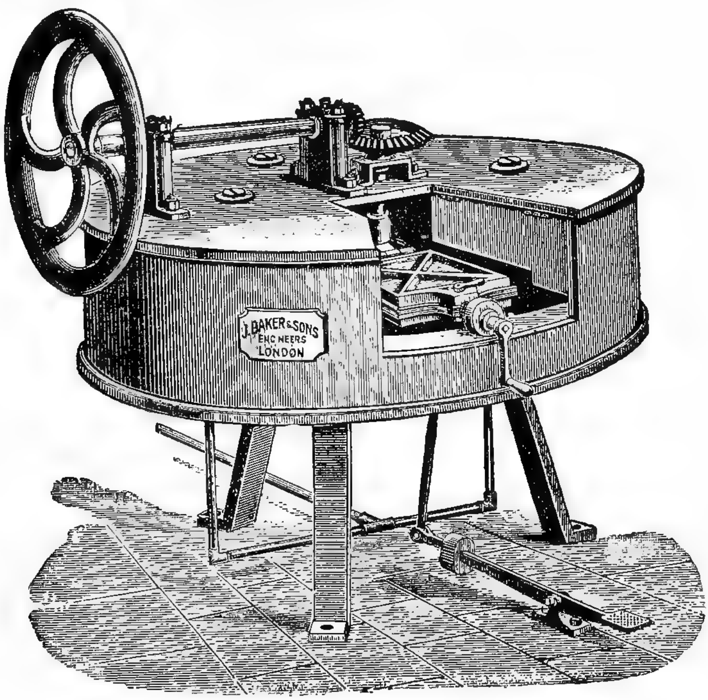


FIG. 6.—Baker's Sugar Wafer Machine.

The machine shown in (Fig. 6) is adapted for baking all kinds of sugar wafers, and is suitable for a small trade, which would not require the large mechanical wafer machine. The plates, four in number, are fixed to a center upright, and are carried on the outer end by a small wheel supported by a suitable track. The plates require to be closed and opened by hand, and the rotation to bring the plates opposite to the opening (where the batter is placed in, and the baked wafer sheet removed) also requires to be performed by hand. The plates are made to turn over during their passage

around, so that both sides of the plates are heated by suitable gas burners fixed at two points below the plates. The gas and air which come together to the gas burners may be regulated to give the exact heat required, so that the baking is done in 4 or 5 minutes—the time usually taken for one revolution of the plates.

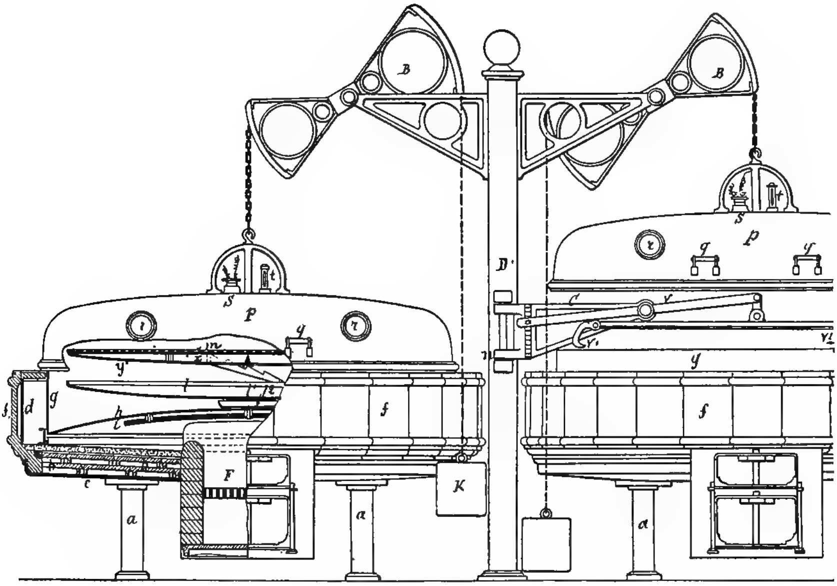
An oven that attracted considerable attention at the Exposition, and which was seen in operation daily at a large bake shop on the Avenue de l'Opera, was that invented in 1883 by Dathis. Its construction is fully described in United States patent, No. 323643, August 4, 1885. In size, these ovens were about 6 feet in diameter (Pl. XLII).

This invention relates to an improvement in devices for baking bread; and the invention consists in the construction, as hereinafter described, and more particularly recited in the claims.

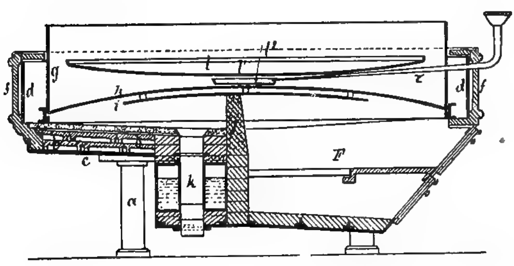
In the drawings illustrating my invention, Pl. XLII, Fig. 1, represents a front elevation of a pair of ovens, one at the left in partial section, the one at the right having a portion broken away to contract the extent of the figure; Fig. 2, a transverse vertical section of one of the ovens; Fig. 3, a plan view of one of the ovens, the cover removed.

The method of preparing the dough constitutes no part of my present invention, it only being necessary that it shall be prepared and permitted to rise, say, in the usual manner.

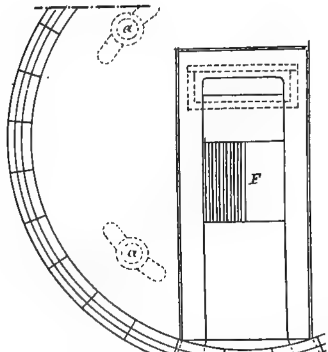
In the ovens of this construction the rays of heat are well distributed, so as to constantly surround the loaves or other articles inserted therein to be baked with an absolutely uniform heat. Each one of such ovens is supported by four or more uprights or columns *a a* of cast iron or other suitable material. It consists of a bottom composed of fire bricks or clay plates *b b* joined together upon a plate *c c* of sheet iron, cast iron, or other metal. The whole assumes a circular shape, and is surrounded with a double cylindrical wall *d* made of sheet iron and of clay plates *f* supported together by means of angle irons, or in any other convenient manner. The inner body of the oven consists of a cylindrical part *g* made of sheet iron, and closed air-tight by means of sole plate *h* of convex configuration, and with a double wall, *i*. The sole plate *h* receives direct the whole of the heat evolved by the fire in hearth F of which the fire bridge *j* firmly leans against the double wall *i*, so as to force the hot gases to spread below the whole of the surface of the sole before they escape through flues *k*, which lead them into the main escape chimney. Above sole plate *h*, I arrange another hollow diaphragm *l* perforated at l' and adapted to distribute the heat throughout the whole bulk of the oven. Such diaphragm may be placed above a small vessel l^2 which may receive at intervals an injection of water while the breads or cakes are being placed into the oven, or at any other desirable moment, with a view to produce instantly a certain moist condition by means of vapor, which spreads all round the cold loaf just brought into the oven. Now, above this diaphragm is placed the upper plate A, carrying in one lot or series all the loaves or cakes to be baked. This plate consists of a convex sheet iron plate *y* and a plain plate *x*, so that a layer of air may be inclosed between the two plates. The object sought to be accomplished, by so providing air between said plates is, first, to make the amount of air uniform all over the area of plate *x* and, second, to oppose to the passage of such heat more or less resistance, according as the empty space between plates *x* and *y* is larger or smaller, and, third, to settle with an absolute certainty the due equilibrium between direct and reverberating heat.



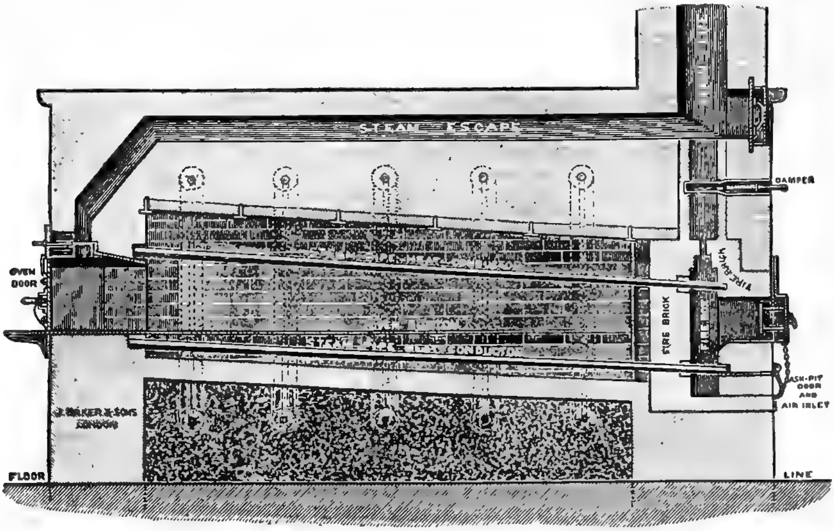
1. DATHIS OVEN, FRONT ELEVATION.



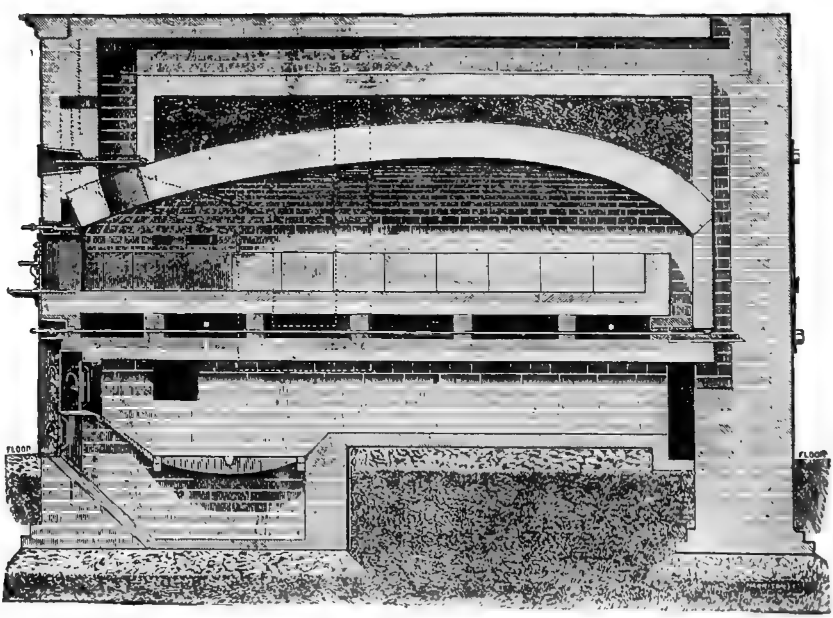
2. DATHIS OVEN, TRANSVERSE VERTICAL SECTION.



3. DATHIS OVEN, PLAN VIEW.



1. PERKINS PATENT STEAM OVEN. SECTIONAL VIEW



2. BAILEY-BAKER CONTINUOUS OVEN. SECTIONAL VIEW.

Above the plate x I arrange a stand m consisting of a metal lattice, grating, open diaphragm, or network, which is interposed between the bottoms of the loaves, cakes, etc., and plate A. By this means the bread, while it is in immediate contact with the plate, as soon as it is placed into the oven avoids the interposition of a cold body between it and this plate, forming a sole plate.

Plate A is removed from and reintroduced into the oven according as it is desirod to place the loaves into the same or withdraw them therefrom. This is effected by means of a bracket C hinged at n n upon a column D and carrying a lever v provided with a strap with clamps v' v'. These and the lever v enable plate A when charged with bread, to be raised and lowered at will. This arrangement of hinged bracket C allows of operating two adjoining ovens at a time. These ovens are, besides, provided on the front side with turning plates, upon which those plates are disposed which are to carry the loaves, so that the latter may be conveniently arranged thereon.

Each oven is suitably closed by a cover p forming the reverberating dome, and capable of moving up and down by means of a beam B with a balance weight. Such cover is provided with handles q q, with looking holes r r fitted with glimmer, and allowing of the inspection of the inside, and with a thermometer t.

To this particular class of baking ovens I apply, by a novel and peculiar method, the use of vacuum incandescent electric lamps, so as to illuminate the loaves, etc., within the oven while the same are being baked. I have shown in the drawings a lamp S of Swan's system, arranged inside the oven and receiving its current from conducting wires charged from any suitable source of electricity.

This class of lamps, which require no air for their operation, enables me to permanently and uniformly light the interior of my baking ovens—a result which, as yet, has been accomplished by none of the lighting methods hitherto known.

The system of heating ovens by steam is not in very extensive use. Plate XLIII, Fig. 2, shows the Perkins steam oven of English manufacture. The method of heating these ovens is by means of a series of wrought-iron pipes, each of which is separate, partly filled with water, and closed at both ends. These pipes incline toward the furnace, and as the water in them becomes heated, it expands and fills the pipes with steam of an equal temperature. This gives a solid heat for baking purposes.

The Bailey-Baker patent continuous baking oven, exhibited in daily operation by Joseph Baker & Sons, did the work required of it in a very satisfactory manner. The flues which communicate the direct heat are so arranged that the oven is entirely under the control of the baker, and the heat can be increased or diminished as desired, in any part or over the whole of the oven chamber, thus securing and maintaining a uniform, even heat throughout the whole oven, or giving more or less heat at any particular point (Pl. XLIII, Fig. 2.)

The Geneste oven, invented in 1881 and patented in the United States in 1882 (No. 265,404) was shown in the French section of the Exposition and was a special attraction to those interested in the subsistence of armies in the field. I give below the description of the American patent and some drawings of this oven (Pls. XLIII, XLIV.)

This invention relates to portable ovens for baking bread and other aliments; and it consists in constructing these ovens in sections, as hereinafter described, whereby they are rendered capable of being transported to localities inaccessible to wheeled

vehicles, and the operations of erecting them and taking them to pieces are also greatly expedited and facilitated.

The ovens usually employed for baking bread for the use of armies during a campaign are either complete ovens permanently fixed upon a vehicle or carriage or are capable of being taken to pieces and divided into a number of small packages, which may be transported upon very light vehicles or upon the backs of mules. The ovens belonging to this latter class as heretofore constructed consist generally of a frame or shell of metal made in separable sections, and employed to form the chamber or vault of the oven, the solid part of the walls of the oven being composed of earth. Ovens of this description consist simply of means for more or less expeditiously constructing an oven with common earth. It is evident that to put these ovens in order for working a loss of time is incurred, first, in putting the shell or frame work together; secondly, in placing the earth in position; and, thirdly, in drying this earth and heating it to the temperature necessary for baking bread. Similar disadvantages also attend the operation of taking down the oven in order to remove it. Now, in the apparatus constructed according to this invention all these disadvantages are removed.

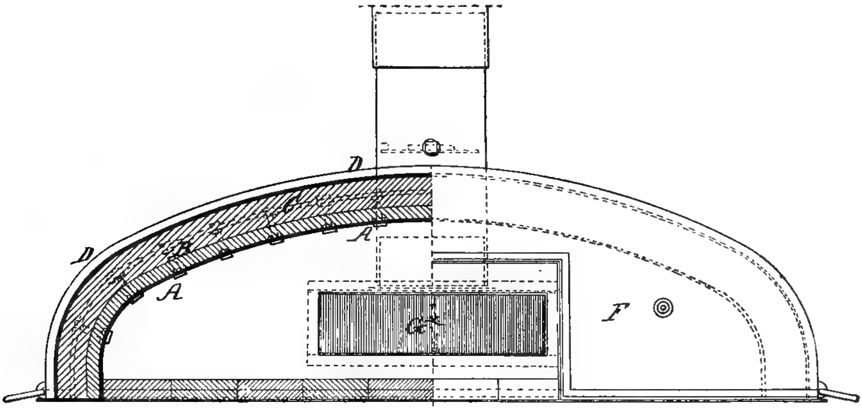
The improved oven is constructed with a series of bays or arched sections, which simply require to be arranged in juxtaposition side by side in order to form a complete oven ready for immediate use. In other words, the improved oven is not composed, as are the ovens ordinarily employed, of sections of the baking chamber only, but is built up with sections of the oven itself, so that it is simply necessary to put the parts together in order to obtain an oven in working order.

In order that the said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures on the annexed sheet of drawings, the same letters of reference indicating corresponding parts in all the figures.

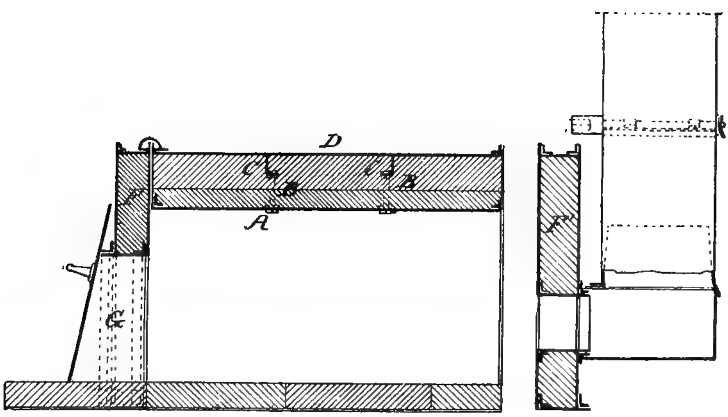
In Plate XLIV, Fig. 1 represents one of the bays or sections of the improved oven, partly in elevation and partly in section, and Fig. 2 is a corresponding longitudinal vertical section. Pl. XLV, Fig. 1, is a plan partly in section, and Fig. 2 is a general view of a combination of the improved sections, arranged for an oven capable of baking ninety rations.

In carrying out this invention the sections of the improved oven are constructed with an arch A of sheet steel, stiffened by iron stays B bolted to a truss C. These sections are in the form of an arch or bay, the weight and dimensions of which are so calculated as to correspond with a given quantity of bread, and to enable them to be manipulated with facility and carried on the backs of mules. The arch illustrated in the drawings is adapted to contain eight regulation loaves, each weighing one kilogram and a half, and the weight of the arch itself does not exceed ten kilograms. On the convex side of the arch of steel plates there is placed a layer of cement or plastic material capable of resisting the action of heat, and also capable of storing up the quantity of caloric requisite for the process of baking the bread. This cement is covered with a layer of suitable nonconducting material, in order to prevent loss of heat by radiation, and the whole is inclosed by a sheet-iron envelope D. An arch or bay thus constructed constitutes a self-sustained section of the sides and roof of the oven, which may be built up with any convenient number of such bays or arches. The bays are arranged side by side, and drawn together by chains *c c'* connected to screws passed through ears or lugs on end walls, hereinafter described, as shown in the drawings, Pl. XLV, Fig. 2. These chains are tightened by turning suitable nuts bearing against the said ears or lugs.

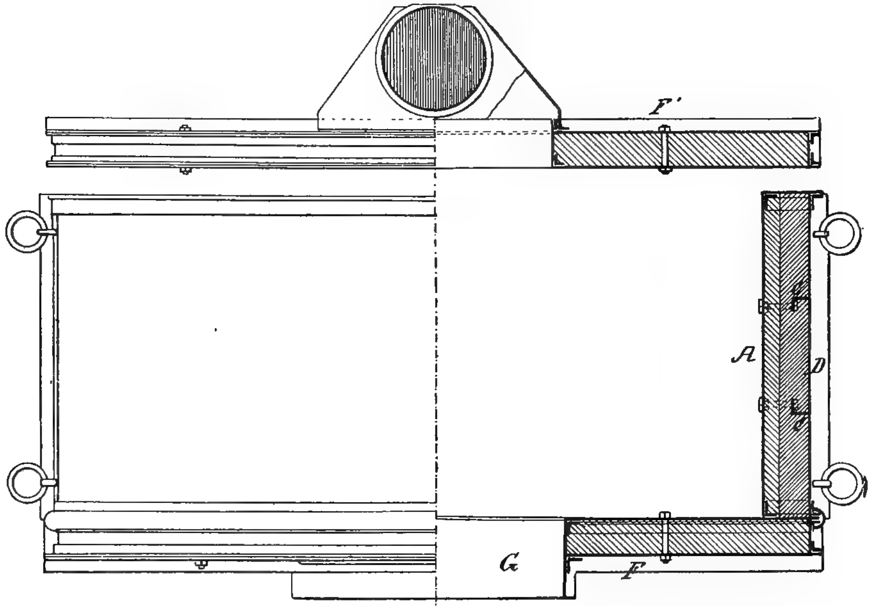
The two extremities of the oven are closed by straight vertical end walls F F' constructed in a similar manner to the arched sections hereinbefore described, being provided internally with layers of fire-proof and nonconducting materials. One of these end walls presents a suitable mouth or opening G for working the oven, and the other end wall is provided with a chimney or flue controlled by a damper.



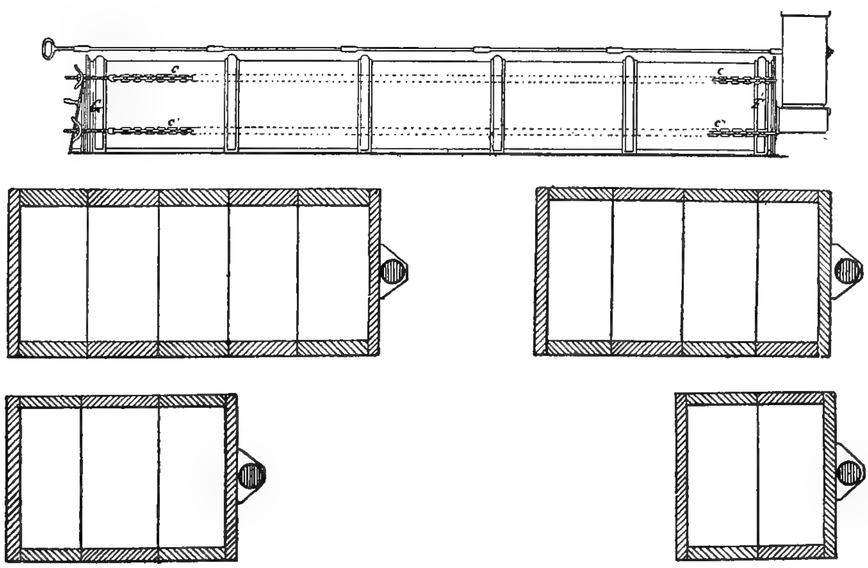
1. GENESTE ARMY OVEN.



2. GENESTE ARMY OVEN.



1. GENESTE ARMY OVEN.



2. GENESTE ARMY OVEN. PLANS.

The oven may be provided with a bottom or floor consisting of earthenware panels or tiles supported in a metal frame or frames; but in certain cases this bottom may be dispensed with by a suitable preparation of the ground upon which the oven is erected. The tiles of the floor are bound together by a fire-proof cement, and metal slips or partitions partially embedded in the floor serve to support the shovels used in working the oven, and thus protect the tiles from injury. Each panel or frame of which the floor is composed may correspond in size to one bay or to half a bay, and the weight of the panels is so calculated as to admit of their being carried on the backs of mules.

The improved oven may be fitted together and worked upon a vehicle when the nature of the ground will admit of such an arrangement.

No ovens of American invention were shown at the Exposition, but we must not infer that there are no good ones made in our country. I will mention only one of the many American ones invented during the past 10 years.

The Duhrkop oven (patented in 1888) is very economical of fuel and does excellent work. It is constructed with hot-air chambers below and above the baking chamber, which is shallow, not more than a foot in height in the center. The oven is described as follows by the patentee (Pl. XLVI-XLVIII):

This invention relates to various improvements in a baker's oven, and more particularly to an arrangement of flues, whereby a uniform heat is imparted to the top and bottom of the oven.

The invention also relates to several details of construction.

It consists in the various features of improvement, more fully pointed out in the claims.

The letter *a* represents the fire-place of a baker's oven, opening towards the rear of the same. From the grate the heat and products of combustion pass first forward and around a fire-wall, *b*, thence backward through the upper part, *a'*, of the fire-place, and thence around a fire-wall, *c*, into a number of parallel flues, *d d*, Pl. XLVII, extending directly beneath the bottom *e* of the baking chamber. This bottom is composed of two walls of fire-brick inclosing a bed of sand. From the flues *d* the products of combustion enter a transverse passage, *d'*, that leads them to two upright flues, *f*, located at the right and left of the baking chamber *g*. From the upright flues *f* the products of combustion pass above the baking chamber *g* and between two arched roofs, *g' h*, divided by a heating space. This heating space has a central partition, *i*, two lateral inclined partitions, *j*, and two short deflecting walls, *k*.

The products of combustion emerging from flues *f* are deflected by walls *k* against inclined partitions *j*, around which they flow, to finally pass forward between such partitions and the central partition, *i*, and out into the smoke-stack *l*. By this construction both the bottom and the top of the baking chamber are thoroughly and properly heated. The fire chamber *a* is also directly connected to the heating space between the arched roofs *g' h* by means of direct upright flues *m*, by means of which the heat may, if desired, be directly conducted to the top of the baking chamber. These flues *m* are provided with suitable dampers.

n is a vent connecting the baking chamber with the smoke-stack and permitting the discharge of the gases.

I attach importance to the mode of constructing the heating space above the oven—that is to say, to the use of the two inclined partitions *j* in connection with the deflectors *k*. I have found that by this construction the heat is thrown against the partition, and, running along their inclined faces, a uniform heating of the oven is produced without any cool or comparatively cool spaces.

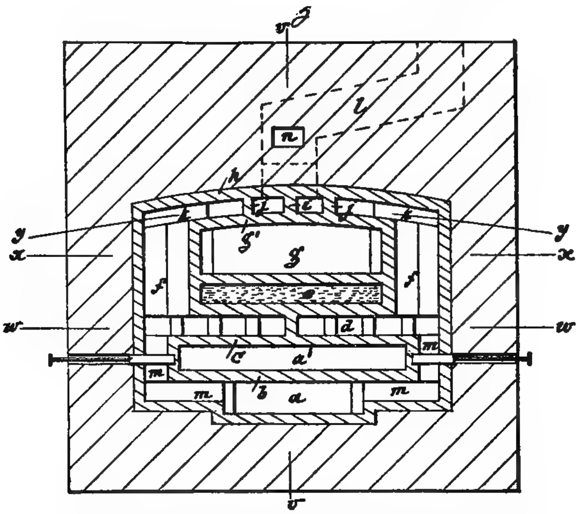
In Pl. XLVIII, Figs. 2 and 3, *o* is the door of the baking chamber *g*, that turns inward on pivot-pin *p*, which is extended at one end beyond its bearing. This extension carries a balance weight, *q*, and has a notched end, by which it grasps a gas-cock, *r*, in a pipe, *s*, the burner of which is placed opposite a mica window in the baking chamber. This burner is never entirely extinguished. When the door is opened, the balance weight will maintain it at any desired inclination, and at the same time the flame from the burner will be turned up as long as the door is maintained by the weight in its open position. When the door is closed, the flame will be automatically turned down.

Fig. 8 shows the mode in which the roof g' is anchored. The series of fire-bricks g^2 composing this roof are flanked at each edge by an angle-iron, g^3, having a hook-shaped projection, g^4, that holds a plate, g^5, bearing against the faces of the fire-bricks and preventing their longitudinal displacement. g^6 is one of a set of upright metal plates placed against the edge of angle-iron g^3. The plates g^6 at opposite sides of the roof are connected by means of bolts and nuts, and thus the entire roof is properly strengthened.

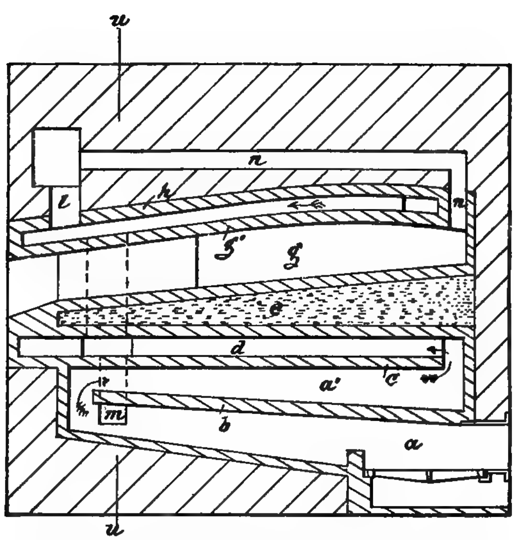
A second patent for the Duhrkop oven was issued in April, 1888. Plates XLIX and L show vertical and horizontal sections of this oven. The description is as follows:

The letter *a* represents the fireplace of the oven, divided from flues *b* at the right and left by means of the partition *c*. The fireplace *a* and the flues *b* are provided with arched roofs *d*, as shown. These roofs separate the fireplace and the flues from a large air space, *e*, situated directly beneath the entire base or floor *f* of the baking chamber *g*, such floor being supported by an offset on the side walls, *h*, of the oven. The baking chamber *g* is provided with a double-arched roof, *i i'*, between which the partitions *j* form a series of flues, *k k'*. The heat and products of combustion travel to the rear of the fire chamber *a*, thence around the partitions *c* to the flues *b*. After having traversed the flues *b* the heat passes upward through vertical flues *l* and into the two outward flues *k'*, thence around partitions *j* to central flues, *k*, and finally out of stack *m*. Thus the oven is properly and uniformly heated at the top and bottom. The air space *e* between the roofs *d* and the base *f* of the oven I deem of considerable importance. The heat which is radiated upward from the fire chamber *a* and flues *b* heats the air in the space *e*. This heated air imparts to the baking chamber *g* a uniform degree of heat, which greatly facilitates and improves the baking operation.

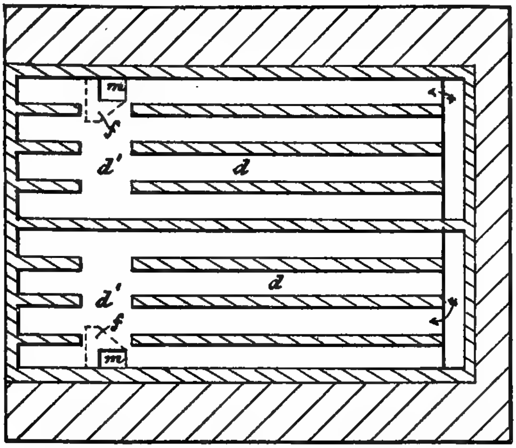
n are dampers in partitions *c* for throwing the heat directly from the fire chamber *a* into the flues *b*.



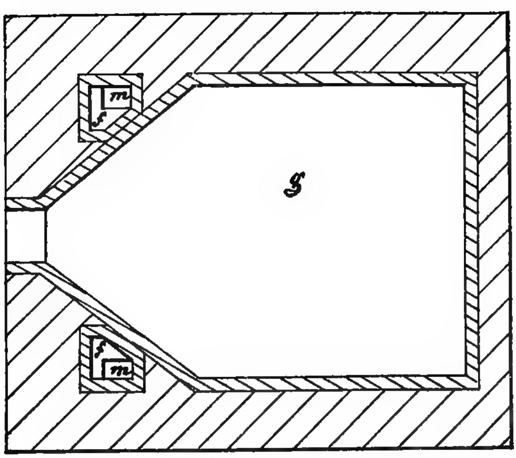
1. DUHRKOP OVEN. VERTICAL TRANSVERSE SECTION.



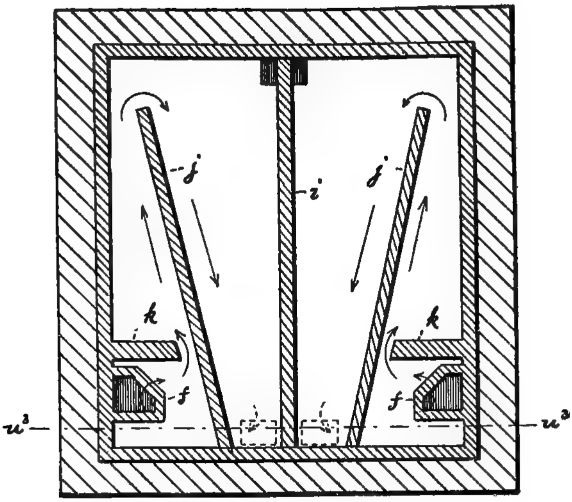
2. DUHRKOP OVEN. VERTICAL LONGITUDINAL SECTION



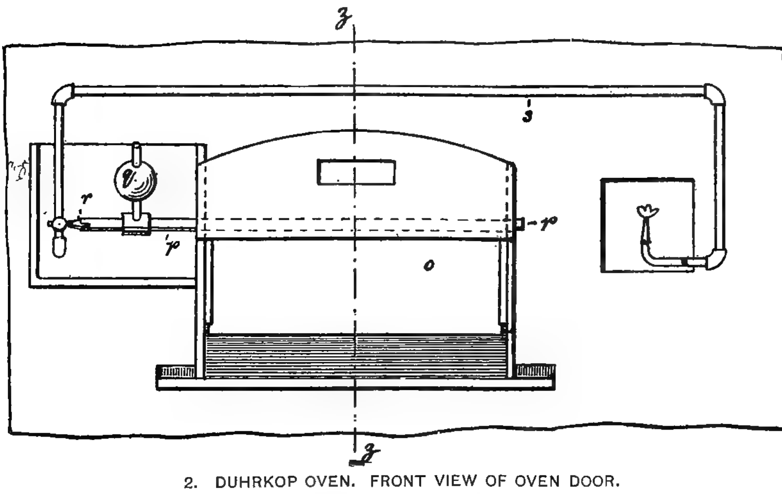
1. DUHRKOP OVEN. HORIZONTAL SECTION.



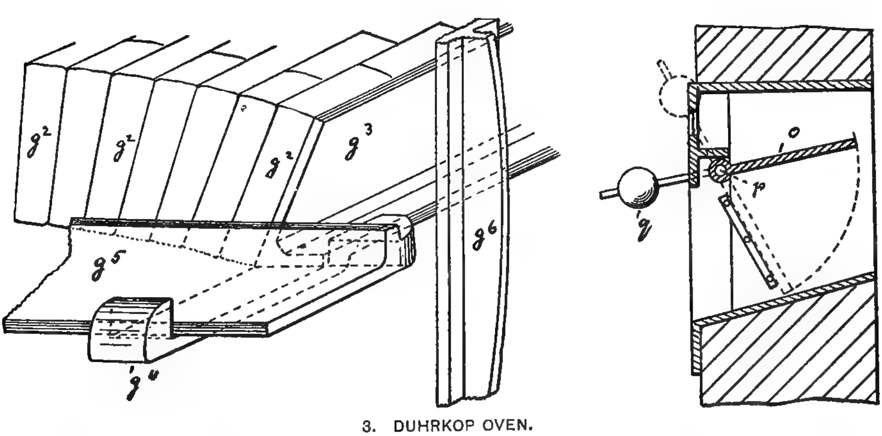
2. DUHRKOP OVEN. HORIZONTAL SECTION.



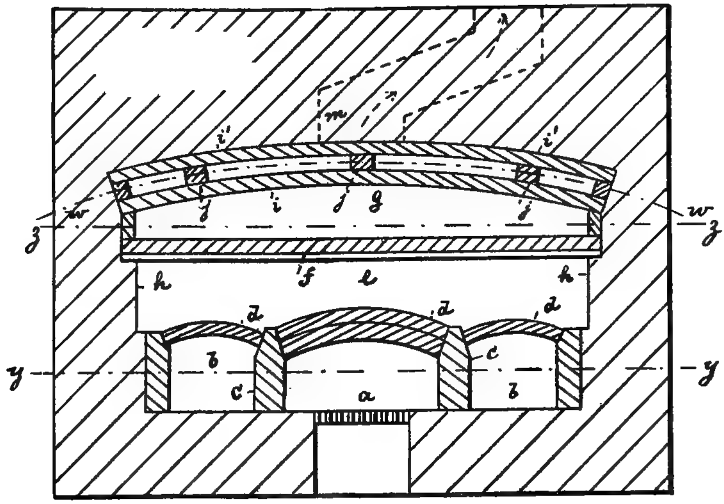
1. DUHRKOP OVEN. HORIZONTAL SECTION.



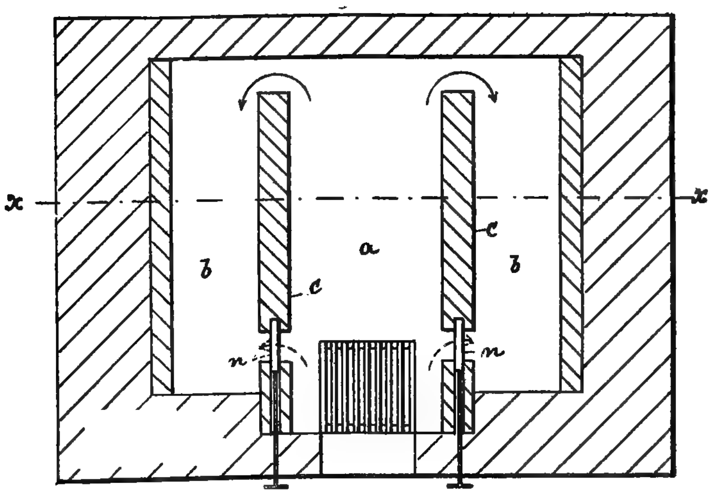
2. DUHRKOP OVEN. FRONT VIEW OF OVEN DOOR.



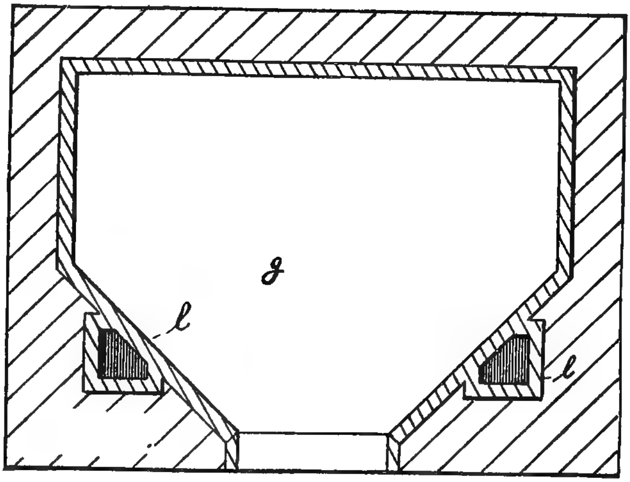
3. DUHRKOP OVEN.



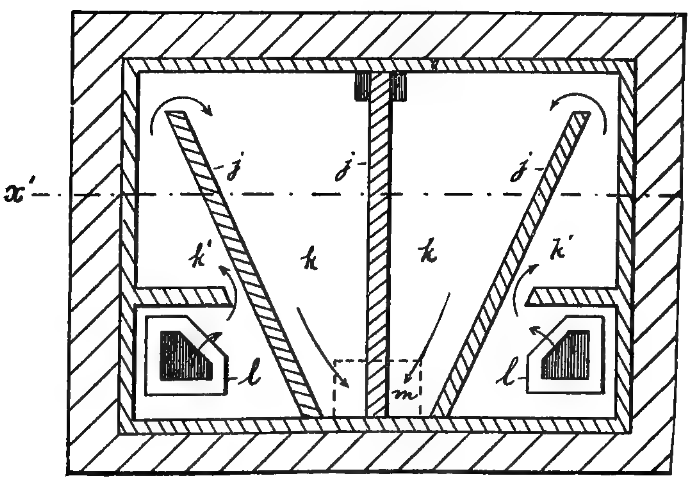
1. DUHRKOP OVEN. VERTICAL SECTION.



2. DUHRKOP OVEN. HORIZONTAL SECTION.



1. DUHRKOP OVEN. HORIZONTAL SECTION.



2. DUHRKOP OVEN. HORIZONTAL SECTION.

CLASS 60.—DAIRY PRODUCTS: OILS AND FATS.

CLASS 69.—DAIRY PRODUCTS: OILS AND FATS.

I.—THE AWARDS TO EXHIBITORS.

Class 69 includes fresh and preserved milk, butter, cheese, eggs, lard, and comestible oils. Twenty-eight countries had exhibits in this class, and the total number of awards given was 955, which includes 11 grand prizes, 155 gold medals, 294 silver medals, 289 bronze medals, and 206 honorable mentions. The distribution of awards among various countries is shown in the following statement:

	Grand prizes.	Gold medals.	Silver medals.	Bronze medals.	Honorable mention.	Total.
Portugal	1	23	51	105	121	301
Algeria		5	18	14	10	47
Spain	1	10	11	8	4	34
France	3	7	9	5		24
Greece		4	3	9	3	19
Mexico		2	2	4	6	14
Italy		6	5	2		13
Netherlands		1	7	3		11
United States		1	5	1	2	[illegible]
Tunis	1	1	4	2		8
Argentine Republic			3	2	1	6
Brazil			1	3	1	5
Uruguay			3	1	1	5
Russia		1	2	1		4
Monaco		1	2			3
St. Marino		1		2		3
French East Indies				1	1	2
Great Britain		2				2
Chile			1	1		2
Austria		1	1			2
Australia			1			1
Belgium			1			1
Colombia			1			1
Denmark		1				1
Dominican Republic			1			1
Roumania					1	1
Salvador				1		1
Senegal					1	1
	6	67	132	165	152	522

In May and again in September there were special exhibits of dairy products at the Exposition, including fresh and salted butters, and

cheeses of many varieties. The difficulty of preserving the articles shown prevented them from keeping this exhibit longer than three or four days. Most of the articles were of French production, being sent from all parts of the country.

In the September display Switzerland showed some excellent cheeses, and some very fine samples of cream and butter were shown by the London Dairy Company.

The countries participating in these *concours* were France, Switzerland, Norway, England, Netherlands, Spain, Russia, Finland, Belgium, and Italy. The grand prize for milk was awarded to Henri Nestle, of Switzerland, for the very superior preparation of children's food made from condensed milk and prepared flour. Gold medals were awarded for Dahl's Norwegian condensed milk, and to Bochet, Fostier, Prempain, and Vayssiere, of France. Two grand prizes for butter were awarded to Bretel frères and the Société d'Agriculture de Bayeux of France. For superior quality of cheese grand prizes were awarded to the Swiss department of agriculture and to Guerault-Godard of France. The distribution of awards for the temporary exhibits was as follows:

	Grand prizes.	Gold medals.	Silver medals.	Bronze medals.	Honorable mention.	Total.
France	3	74	138	99	39	353
Switzerland	2	10	14	15	13	54
Netherlands	......	1	2	4	......	7
Belgium	......	......	2	2	2	6
Spain	......	1	2	1	......	4
Italy	......	......	3	......	......	3
Finland	......	......	1	3	......	4
Russia	......	1	......	......	......	1
England	......	1	......	......	......	1
	5	88	162	124	54	433

One of the popular features of this section of the Exposition was its excellent dairies, there being three in active operation during the whole summer, namely, the Swedish dairy, the Hollandish dairy, and the English dairy.

The latter was very fully equipped in everything pertaining to a dairy. A number of fine Jersey cows supplied the rich milk, from which butter, whipped cream, and milk were prepared for hungry sight-seers.

II.—FRESH MILK, CONDENSED MILK, KOUMISS

Milk in its three principal forms, natural milk, butter, and cheese, constitutes one of the most important of all foods. Pure milk contains all the elements of nutrition, and in the easiest form of digestion. Cow's milk is the most commonly used, but the milk of sheep, goats, camels, mares, asses, and of other animals is also largely consumed in some countries. The Arabs and some of the people of

India eat camel's milk. In Tartary mare's milk is a common food. The beverage known as koumiss is made by fermenting mare's milk.

Goat's milk is a common diet in all countries where that animal is found. In Sicily, Switzerland, and in France, goat's milk is more common than the milk of the cow. In the suburbs of Paris herds of goats are kept to supply the demand for their rich milk. It is a common thing in Paris to see children drinking cups of goats' or asses' milk, bought from the drivers as the animals are driven through the streets.

Milk may be kept fresh for a considerable time by heating it to 195° F. and cooling it only after this heating. The chemical composition of the milk is changed by this process, and it has a cooked taste.

Salicylic acid will preserve milk, and so will bi-carbonate of soda or lime water, but such preservatives are not much used. Boiled milk will keep fresh sufficiently long for household use. Aëration, as described by Mr. Cheesman on a subsequent page, is also a good method of preservation.

Refrigeration and concentration by evaporation are the best methods of keeping milk, and are both extensively employed. Milk will keep sweet in the pans for a short time by adding a little borax.

The Swiss prepare a medicinal condensed milk for the use of infants and convalescents, by adding, besides sugar, a certain quantity of wheat flour, powdered leguminous plants, and soluble preparations of iodine, iron, etc.

Among the many patents issued in the United States for preserving was one given in 1887 to Camrick for powdered milk, which is condensed *in vacuo* at a low temperature, and sugar is then added. Powdered milk has been made in Switzerland but has never been much used.

Condensed milk is the application of the process of evaporation, the excess of moisture being removed. Fresh milk is put in vessels holding 750 to 1,000 gallons, and maintained at a slightly raised temperature by steam heat, and undergoes evaporation *in vacuo*. The process lasts 2 to 5 hours. Powdered refined sugar is then added, in proportion of about one third the weight of the condensed milk. When the mass is as thick as dense honey, it is put in tin boxes and hermetically sealed. In the presence of heat and sugar, the casein sometimes decomposes, especially if the milk is not perfectly sweet. The fat sometimes distills with the water if the heat be allowed to exceed 100° F. Condensed milk is also prepared in Switzerland and elsewhere without the addition of sugar.

Mobrun's process of preserving is to warm the milk at a moderate temperature in a tin vessel furnished with a leaden tube, for the expulsion of the air. The tube is then compressed and the orifice is soldered up. In this way the milk will keep good for six months.

Morfit's process is to dissolve 1 pound of gelatin in 1 gallon of milk at 130° to 140° F. The mixture when cool becomes jelly, which is cut into slices and dried. The compound is used to gelatinize more milk, and this is repeated till the gelatin is in proportion of 1 pound to 10 gallons of milk.

Egrot, of Paris, exhibited a machine for condensing milk by concentration in *vacuo*.

KOUMISS.

In Europe and America koumiss is made by fermenting cow's milk. Mare's milk is better because of its large precentage of milk sugar. The common method of making koumiss in the East is to put the milk in leathern vessels, and to add a portion of a previous brewing and also some yeast.

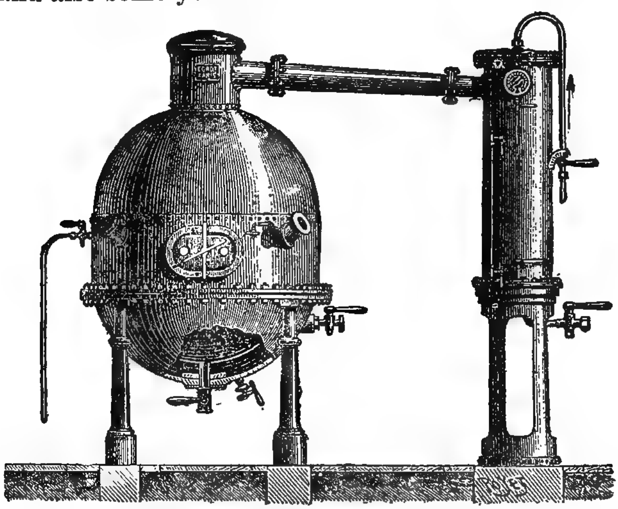


FIG. 7.—Egrot's Milk-Condensing Apparatus.

"The use of koumiss," says Professor Wiley, "both as a beverage and in the sick room is rapidly increasing in this country."

The following analyses of koumiss have been made by Professor Wiley:

Sample No.	Alcohol.	Lactic acid.	Sugar.	Albuminoids.	Fat.	CO^2.	Water.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	1.84	0.91	1.24	1.97	1.26	0.95	[a]92.47
2	2.64	0.80	3.10	2.02	0.85	1.03	88.72
3	1.38	0.82	3.95	2.89	0.88	0.77	[a]89.55
4	2.86	1.04	0.79	1.91	1.19	....	91.87
5	0.76	0.47	4.38	2.56	2.08	0.83	89.32

NOTES.—No. 1, mean of 14 analyses of koumiss from mare's milk; No. 2, mean of 2 analyses of koumiss from cow's milk; No. 3, mean of 9 analyses of koumiss, origin unknown, probably from skimmed cow's milk; No. 4, mean of 9 analyses of koumiss made from mare's milk, London Exposition of 1884; No. 5, mean of 8 analyses of koumiss from cow's milk, made by Division of Chemistry, United States Department of Agriculture.

American koumiss differs from that of other countries in the following points, viz:

(*a*) The percentage of alcohol is quite low and as a consequence the percentage of sugar is high.

(*b*) American koumiss contains more fat; showing that it has been made from milk from which the cream had not been so carefully removed as in those milks from which the European koumiss was made. Mare's milk, as will be seen by the above analyses, contains much less fat and more sugar than that of the cow, thus making it more suitable for the production of koumiss. Good cow's milk, however, is suitable for the manufacture of koumiss after most of the cream has been removed. Should it be desired to make a koumiss richer in alcohol, some milk-sugar could be added.

The samples analyzed were kindly furnished me by Mr. Julius Haag, of Indianapolis. This koumiss makes a delightful refreshing drink. When drawn from the bottle and poured a few times from glass to glass it becomes thick, like whipped cream, and is then most palatable. It is much relished as a beverage, and is highly recommened by physicians in cases of imperfect nutrition.*

III.—BUTTER AND OLEOMARGARINE.

DAIRY BUTTER.

The methods of making butter vary much throughout the world, but the object is always the same, viz, to break the membranous sacs in which the butter is disseminated through the milk, and to enable their contents to coalesce.

In the United Kingdom, the annual product is estimated at 1,500,000 to 2,000,000 cwt. Ireland is an important butter country and exports large quantities. The imports of butter into Great Britain in 1887 were 312,156,000 pounds.

France is noted for its excellent butter; the first quality comes from Isignay and includes the best produce of Normandy and Calvados, while the second quality is the Gourmay butter.

Dutch butter is of three kinds (1) "grass" butter, made from cream when the cows are at grass; (2) "hay" butter, made from cream when the cows are being stall fed; (3) "whey" butter, made from the whey of new-milk cheese.

In European countries, especially in France, great quantities of butter are consumed fresh, or merely washed in brine to keep it for a few days. The home supply is purchased from day to day the same as milk and other perishable foods. For export trade, however, methods of preserving are practiced, the most common method being the use of salt, though great quantities are put up fresh, hermetically sealed, in jars.

In the United States, nearly 1,000,000,000 pounds of butter are made each year. The exports in 1880 were 39,236,658 pounds, but in 1888 they were reduced to only 10,455,651 pounds.

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* U. S. Department of Agriculture, Division of Chemistry, Bulletin 13, Part 1.

The National Butter, Cheese and Egg Association issues the following instructions to shippers of butter:

Packages should be well made, handsome, and uniform. The best wood of which to make them is white oak. White ash answers a good purpose, but white wood and other soft woods should not be used, as they soak largely and impart injurious flavors. The covers should be of the same wood as the sides of the packages. Welsh tubs, or tubs with straight staves largest at top, with flat hoops, the cover or lid having a rim and shutting over and fastened on with strips of tin or wire, have grown in popularity, being well liked by the export trade. They answer well for either early-packed or fresh butter. Some creameries making the very highest grade of fresh butter use them. Firkins of white oak, with smooth, round, hickory hoops, are largely used for packing butter which is to be held over the summer. They are being displaced, to some extent, by Welsh tubs, but are still much liked by many classes of trade. Half-firkin tubs are mostly used for fresh butter throughout the East, but in the West Welch tubs are almost exclusively used. Exporters are more disposed to take butter in half-firkin tubs and firkins than formerly, but still generally express a preference for Welsh tubs. White oak painted or varnished pails are less popular than formerly. They are returned by the purchaser and used over and over again. They are economical to dairymen and creameries located near enough to market to permit of their being returned, but are troublesome to sellers and grocers in the city. They can be used only by local trade, and are therefore suitable only for the freshest and highest grades. There have been tubs for butter made of tin and of tin covered with a veneer of wood, but they are unpopular. The brine of the butter finds access to the iron beneath the tin and develops rust, which causes a bad flavor. They also become easily dented, and in hot weather the heat strikes quickly through the metal and softens the butter. Crocks are a nuisance, and should never be used. Roll butter, which is becoming less in quantity every year, but which still has some sale during the winter, is best packed in half-barrels. The rolls should be smooth, and each one wrapped in a clean white cloth wet in strong brine. They should be laid neatly, and packed so tightly in the package that they cannot shift. All of the rolls in the package should be, as nearly as possible, uniform in quality. All packages should be very clean and new (excepting return pails). A greasy exterior is very objectionable. Packages held in the dairy should be numbered or dated by proper marks, so that the seller may know which package to open to find the quality and color wanted. If firkins are sawed in two and made into tubs, the hoops which are to be nearest the head should be lengthened and driven up close to the head, partly because the package is thus made air-tight, and partly because otherwise it is easily seen that the tubs are sawed firkins. But it is seldom advisable to saw firkins unless they contain fresh-flavored and fine butter. The top head or lid of a package should never touch the butter. Butter may be advantageously kept under moist salt while at the diary, but when finally closed up for market the salt should be carefully removed, and a cloth wet in strong brine spread over the top. Salt should not be used on the cloth, as it is liable to become distributed through the butter. Store packers should very carefully assort the butter that comes to them, so as to have but one color and quality in a package. Butter uneven in color always sells badly. Do not mix new and old, nor white and yellow when avoidable. All white compounded sells fully as well as mixed. Butter made at creameries is in much favor when made from soured cream. When fresh it generally commands the highest market price. That made from sweet cream loses its flavor very rapidly and does not sell so high. In working butter it is important that all of the buttermilk should be worked out, but it is also important that the grain of the butter be preserved. In salting butter during the spring, fall and win-

ter seasons, three-quarters to an ounce of salt to one pound of butter should be used according to the amount of "washing" the butter receives; but the quantity of salt should be increased, say, one-eighth to a quarter of an ounce during the summer. The salt used should be of the purest and finest quality. Poor salt greatly injures the flavor and sale of butter. It is important that the salt be kept in a clean and pure place. Salt absorbs moisture, and with it any bad flavors which it may have acquired. Factory butter, or that which is collected in rolls from farmers and worked over by the various processes in vogue at the West, is best in winter, when grain-feeding of the cows gives the butter sufficient body to stand the second working. That made in this way in hot weather is very poor and salvy, and sells very low. Butter packed in small western dairies and collected by dealers into lots for shipment is often of good quality, but very irregular in the size and style of package. This objectionable feature is easily, and it should be promptly, corrected. Butter of this kind, as well as all factory lots, should be carefully graded, so that the invoices shipped be uniform in quality. During the hot weather it pays to ship butter in refrigerator cars, its better condition on arrival more than compensating the additional cost of freight.

OLEOMARGARINE AND OLEO OIL.

The oleomargarine industry owes its origin to the French chemist, Mège-Mouries, who in 1870 first described a method of making artificial butter on a large scale. After many experiments he found that a certain part of beef fat, melted at the same temperature as butter, could be made into a good substitute for ordinary butter and that it would not become rancid for a long time. He established a factory at Poissy, just before the Franco-Prussian war, but little was done until the close of the war. In 1872 the municipal board of health authorized the sale of margarin, as this new food was called, on condition that it be not sold as butter. The method employed by Mège is thus described by Prof. Wiley:

The fat of best quality from recently killed bullocks is finely cut in a kind of sausage grinder, in order to break up the membranes The fragments fall into a tank heated with steam. which for every 1,000 parts of fat, contains 300 parts of water and 1 part of carbonate of potash, and two stomachs of sheep or pigs.

The temperature of the mixture is raised to 45° C. After two hours, under the influence of the pepsin in the stomachs, the membranes are dissolved and the fat melted and risen to the top of the mixture. The fat is next drawn off into a second tank, kept at a somewhat higher temperature, and 2 per cent of common salt added. After two hours more the fat becomes clear and takes on a yellow color, and acquires somewhat the taste and odor of butter. The fat is now drawn off into vessels and allowed to cool. It is then cut into pieces, wrapped in linen, and put in a hydraulic press and kept at a temperature of about 25° C. By pressure the fat is separated into two portions, viz. stearin 40 to 50 per cent, and fluid, also 50 to 60 per cent.

The stearin remaining in the process is used in candle-making.*

I give below the full text of Mège's patent, as granted by the United States Patent Office, December 30, 1873:

To all whom it may concern:

Be it known that I, Hippolyte Mège, of Paris, France, have discovered a new and improved process of transforming animal fats into butter, of which the following is a full. clear, and exact description:

*U. S. Department of Agriculture, Division of Chemistry, Bulletin No. 13.

The butter which is obtained from milk is produced by the cow elaborating her own fat through her cellular mammary tissues at the low rate of temperature of the body.

The animal fat from which the butter cells in milk are produced is composed chiefly of olein, margarin, and stearin, and small quantities of other substances.

The natural process performed by the cow consists, mainly, first, in separating the oleomargarine from the stearin without developing disagreeable odors or flavors in the oleomargarine; and, secondly, in producing a slight change in the oleomargarine, by which it assumes the character of butter.

My invention, hereinafter described, is based upon a discovery made by me, that when the fat is rendered at a low temperature, considerably below that heretofore employed in the ordinary rendering of fat, it has the taste of molten butter, and does not acquire that peculiarly disagreeeble flavor heretofore supposed to be necessarily attached to melted fat or tallow, and which is designated as "tallowy flavor."

I have succeeded in obtaining excellent results by rendering the crude fat at a temperature of 103° F., which is below the temperature at which the tallowy flavor is created. The temperature may be raised above this point in order to facilitate the operation, provided care be taken to avoid attaining the temperature at which the tallowy flavor is created.

The precise limit to which it is safe to increase the rendering temperature can be ascertained by trial under various circumstances with the different kinds of fat. The temperature must, however, be far below that heretofore ordinarily used in rendering fats when no such object as I propose—to wit, the making of a butter-like product—was had in view. I do not think it would be safe to vary many degrees above that specifically indicated.

I have also discovered that, in order to neutralize any fermentation of the fat before or during its treatment, the raw fat should, as soon as possible after the death of the animal, be plunged in a solution of fifteen (15) per cent of common salt and 1 per cent of sulphate of soda, the effect of which would be to prevent such fermentation.

In carrying out my process I first crush, grind, or disintegrate the fat by any suitable machinery, such as rollers or millstones, in order to break up the cellular tissues in which the fat is contained in the animal, and thus cause it to be more easily melted or rendered by the application of low temperatures. This fat thus disintegrated is to be slowly raised to a temperature of 103° F. in a vessel in which the temperature can be raised at will until the rendering shall be complete. The temperature, as before stated, must be so regulated that the rendered fat will have the taste of molten butter, and care should be taken not to heat it so as to induce the change which produces the usual disagreeable taste of melted fat or tallow, instead of the taste of molten butter, which temperature is considerably below that heretofore ordinarily used in rendering fat, and will be found to vary not many degrees above the point already stated.

I also add to the fat while being rendered, for the purpose of aiding in this process, two liters of gastric juice to one hundred (100) kilograms of fat. This gastric juice is made by macerating, for three hours, half of the stomach of a pig or sheep, well washed, and three liters of water containing thirty grams of biphosphate of lime. After maceration this macerated substance is passed through a sieve, and then added to the fat under treatment in the proportion of two liters to one hundred (100) kilograms.

The separation of the organized tissues from the fat is aided by the introduction of salt during the rendering; and as soon as there are no lumps of fat visible in the kettle I add about 1 per cent of common salt. I stir it for some time. The rendered fat is then allowed to stand until it attains perfect limpidity, when it can be

drawn off. By this means the separation is well made, and the organized tissues which do deposit are not altered. I then allow the melted fat to stand in a vessel, maintained at a temperature of about 86° to 98°, until the stearin is crystallized. The mixture of stearin and oleomargarine may then be put in a centrifugal machine; and by the operation of this machine the oleomargarine will pass through the cloth and the stearin remain within; or the mixture may be subjected to pressure in a press. The effect produced in either case is that the oleomargarine practically separates from the stearin and flows out. The oleomargarine thus separated from the stearin, when cooled, constitutes a fatty matter of very good taste, which may replace the butter used in the kitchen. If it is desired, however, to transform it into more perfect butter, I employ the following means: I mix the oleomargarine, as it comes from the press or centrifugal machine, with milk and cream, equal to 10 per cent of the weight of the oleomargarine, the temperature of the milk and cream being about seventy-one (71) degrees, and thoroughly agitate them together. I then let the mixture become completely cold and solid, and then cause it to be worked between rollers. which give it the homogeneousness and the consistency which are the qualities of the natural butter.

The above process of agitating the oleomargarine with milk is intended to be adopted when the butter is to be immediately used. If the butter is intended to be preserved, it will be better to mix the oleomargarine at animal heat with 10 per cent of its weight of water instead of milk or cream, and then agitate the two together, as above described.

I have also found it expedient to mix with the cream or milk, in the first case above described, before agitating, or with the water in the other case above described, before agitating, a fiftieth part of mammary tissue, which is the udder of the cow, minced fine, a one-hundredth part of bicarbonate of soda, and some coloring matter.

It may be desirable to add ordinary butter, and this I do by mixing the oleomargarine and the ordinary butter together at a temperature of about 70° F.

What I claim as my invention, and desire to secure by letters patent, is:

(1) The rendering of animal fat at a low temperature, substantially as above set forth, for the production of a fatty matter devoid of a disagreeable taste.

(2) As a new product of manufacture, fat rendered at the low temperature, substantially as above described, devoid of disagreeable taste.

(3) The combined process of rendering animal fat at a low temperature and then separating the oleomargarine for the purpose of producing a material adapted to be used as ordinary butter for culinary purposes, or to be further treated for making more perfect butter, substantially as above described.

(4) As a new product of manufacture, oleomargarine obtained from fat rendered at a low temperature and separated from the stearin, substantially as above described.

(5) The agitating of oleomargarine with water or milk for the purpose of making a more perfect imitation of butter, substantially as above described.

(6) The butter-like product produced by the agitation of oleomargarine with water or milk, substantially as above described.

(7) The treatment with artificial gastric juice for facilitating the process of rendering the fat at a low temperature, substantially as above described.

(8) The treatment of the oleomargarine with the mammary tissue of the cow, or mammary pepsin, substantially as above described.

(9) The addition of ordinary butter to oleomargarine, substantially as above described.

Numerous patents have been granted in the United States and foreign countries, since 1874, claiming improvements in the manu-

facture of artificial butters. I will not enumerate them here, but for American patents will refer to the Agricultural Bulletin above noted, and for foreign patents to *Arbeiten a. d. Kaiserlichen Gesundheitsamte*, pp. 481–493.

In the United States oleo oil is made from the caul fat of cattle. It is taken from the animal just slaughtered, and, after a careful cleaning, is plunged in a succession of vats of cold water until the animal heat is driven out.

The fat is then cut in pieces by a machine and packed in broken ice, and is afterwards, at a temperature much below boiling, pressed through a machine which crushes it so as to separate the fibrous matter of the fat. It is then strained and sifted and run into the refining kettle, where it is stirred and heated to about 150° F. The fat dissolves at this heat and settles at the bottom of the kettle, whence it is siphoned into vats and gradually solidifies. In about 48 hours it has become a pale yellow, and almost tasteless granulated solid, which is put in linen bags and submitted to heavy pressure between metal plates. The oil thus extracted is oleo oil, used in making artificial butter, and the fibrous material in the bags is oleo stearin, used in lard manufacture.

The three commercial grades of oleo oil differ in fineness of granulation and in delicacy of taste. The best grade is made entirely of inner fat, while the other qualities have a mixture of inner fat, kidney, and other fats.

A working model of an oleomargarine factory was exhibited in Class 69. It was a reproduction in full detail of the extensive factory of M. Pellerin, at Aubervillers, near Paris. There was shown, first of all, the warehouses for the reception of the fat, the machines for defibrating it, then the steam cooking vats. The fats are then subjected to hydraulic pressure to separate the stearin from the oleo oil. The stearin is used chiefly in the manufacture of candles. The oil is cooled and churned with cream butter, producing the artificial butter known commercially in France as oleomargarine. The butter made in this factory was of excellent quality, and would deceive even experts.

In Germany, Belgium, France, and especially in Holland, large quantities of oleomargarine are manufactured. Holland buys the oleo oil from the United States and exports the manufactured product to other European countries.

"Oleomargarine" is the name originally given to the artificial butter made from oleo oil mixed with milk and cream, to which is sometimes added a little cream butter. The mixture is salted and colored in imitation of cream butter. Very little genuine oleomargarine is now manufactured. "Butterine," which is a mixture of the same materials but in different proportions, and with the addition of "neutral," made from hog fat, is not subjected to pressure, as in making

oleo oil. When the fat is drawn from the kettles, it is subjected to low temperature in large vats surrounded by a freezing mixture, and crystallizes in snow-white flakes without taste or perceptible odor. After remaining in the vats about 24 hours, it is taken out and placed on shelves to drain, after which it is ready for use. Neutral melts at the same temperature as cream butter.

In making oleomargarine, the oleo oil and neutral are melted in separate heaters at a temperature of about 70° F. The proportion of milk and cream added is from 10 to 20 per cent. The requisite quantity of cream is churned until butter commences to form, when the oleo oil is poured in, and when the cream and oil are well mixed, the neutral is added, and then a small quantity of cream butter. The whole is colored with annatto, as in ordinary butter-making. During the operation, which takes from a half hour to an hour and a half, the temperature is carefully regulated; from 85° F. it is raised to 105° F.

Cotton-seed oil is sometimes added to the oleo oil to soften the granules and thus make the product more flexible, but the same end will result by using a larger proportion of cream butter. When the materials are well mixed in the churn, the mixture is turned into vats filled with crushed ice, so as to give a fine grain to the product. When completely solidified, in 30 to 48 hours, it is placed to drain on wooden trays, and is then salted and worked with mechanical rollers, the same as cream butter, to drive out the water, and is then cut or molded in the form desired. It is kept in cold storage at a temperature of about 38° until barreled or boxed.

There are no reliable statistics to show the extent of this industry in the United States before 1886. In 1880 the exports were 39,236,655 pounds of butter and 20,000,000 pounds of oleomargarine. In 1885 the exportation of butter had decreased to 21,638,128 pounds, while that of oleomargarine and oleo oil had increased to 38,000,000 pounds. It is estimated that in New York City alone 10,000,000 pounds of oleomargarine were sold in 1883 and 45,000,000,000 pounds throughout the United States. The value of exports of these products rose from $70,000 in 1876 to $4,451,000 in 1885.

The exports of oleo oil as shown below increased from 19,714,338 pounds in 1882 to 45,712,985 pounds in 1887. The exports of oleomargarine as made into butter decreased from 2,157,446 pounds in 1882 to 761,938 pounds in 1885 and increased to 1,729,327 pounds in 1888.

Exports of oleo oil from the United States during the years endiug June 30, 1882 *to* 1888:

	Pounds.		Pounds.
1882	19,714,338	1886	27,729,885
1883	29,031,064	1887	45,712,985
1884	37,785,159	1888	30,146,595
1885	37,120,217		

In 1887 the exports of oleo oil from the United States to Europe, chiefly to Holland, were 45,712,985 pounds, valued at $4,676,131, and in 1888, 30,146,595 pounds, valued at $3,230,123.

The exports since 1882 have been as follows:

Statement showing the quantity of oleomargarine produced and withdrawn tax-paid for export, monthly, from November 1, 1886, *to June* 30, 1889.

Month.	Quantity produced.	Withdrawn tax-paid.	Withdrawn for export.
1886.	*Pounds.*	*Pounds.*	*Pounds.*
On hand November 1	181,090		
November	3,188,261	2,986,241	6,747
December	3,073,263	2,956,827	67,189
1887.			
January	2,804,096	2,720,235	144,535
February	2,779,855	2,716,759	60,500
March	3,568,254	3,512,138	96,499
April	2,839,358	2,780,307	149,838
May	1,885,027	1,769,954	136,523
June	1,375,423	1,30[illegible],108	62,701
July	1,208,638	1,170,136	33,240
August	2,425,226	2,296,238	110,990
September	2,703,256	2,568,007	68,917
October	3,082,935	2,915,016	92,201
November	3,003,715	2,862,321	148,899
December	3,206,028	3,120,393	78,500
1888.			
January	3,058,9[illegible]5	2,918,868	117,781
February	3,057,149	3,003,515	126,168
March	3,940,727	3,824,672	155,761
April	3,273,453	3,062,396	251,994
May	3,185,127	2,817,292	327,726
June	2,130,318	1,930,311	174,021
July	2,084,317	1,925,762	155,200
August	2,301,769	2,209,782	153,285
September	2,776,465	2,611,693	167,787
October	3,462,123	3,368,418	80,785
November	3,734,874	3,509,408	175,965
December	4,181,317	4,025,336	109,385
1889.			
January	3,607,753	3,353,550	137,123
February	3,523,381	3,266,245	228,191
March	3,047,875	3,077,831	70,424
April	3,057,841	2,886,481	285,948
May	2,310,945	2,114,678	126,223
June	1,575,362	1,514,658	58,579
	91,684,180	87,096,376	4,159,625

France in 1887 exported 8,151,460 kilograms of margarine, valued at 10,599,909 francs.

The United Kingdom in 1888 imported 1,138,174 hundredweight of margarine, valued at £3,263,826.

Holland in 1888 imported 2,950,000 kilograms of oleo oil from the United States, and 55,000 barrels, or 9,000,000 kilograms of cotton-

seed oil from the United States, England, and Turkey, which was used almost entirely for the manufacture of artificial butter.

In the United States a national law, given below in full, was passed by Congress in 1886 regulating the manufacture and sale of oleomargarine. Most of the States have also enacted laws. In Maine, Michigan, Minnesota, Wisconsin, Missouri, Pennsylvania, New York, Delaware, and Ohio, there are prohibitory laws. Vermont prohibits the sale of oleomargarine as butter. The laws of New Hampshire require that oleomargarine shall be colored pink. Some States provide restrictions as to marking of packages.

AN ACT defining butter, also imposing a tax upon and regulating the manufacture, sale, importation, and exportation of oleomargarine.

Be it enacted by the Senate and House of Represenentatives of the United States of America in Congress assembled, That for the purposes of this act the word "butter" shall be understood to mean the food product usually known as butter, and which is made exclusively from milk or cream, or both, with or without common salt, and with or without additional coloring matter.

SEC. 2. That for the purposes of this act certain manufactured substances, certain extracts, and certain mixtures and compounds, including such mixtures and compounds with butter, shall be known and designated as "oleomargarine," namely: All substances heretofore known as oleomargarine, oleo, oleomargarine-oil, butterine, lardine, suine, and neutral; all mixtures and compounds of oleomargarine, oleo, oleomargarine-oil, butterine, lardine, suine, and neutral; all lard extracts and tallow extracts; and all mixtures and compounds of tallow, beef-fat, suet, lard, lard-oil, vegetable oil, annotto, and other coloring matter, intestinal fat, and offal fat made in imitation or semblance of butter, or when so made, calculated, or intended to be sold as butter or for butter.

SEC. 3. That special taxes are imposed as follows:

Manufacturers of oleomargarine shall pay six hundred dollars. Every person who manufactures oleomargarine for sale shall be deemed a manufacturer of oleomargarine.

Wholesale dealers in oleomargarine shall pay four hundred and eighty dollars. Every person who sells or offers for sale oleomargarine in the original manufactuer's packages shall be deemed a wholesale dealer in oleomargarine. But any manufacturer of oleomargarine who has given the required bond and paid the required special tax, and who sells only oleomargarine of his own production, at the place of manufacture, in the original packages to which the tax-paid stamps are affixed, shall not be required to pay the special tax of a wholesale dealer in oleomargarine on account of such sales.

Retail dealers in oleomargarine shall pay forty-eight dollars. Every person who sells oleomargarine in less quantities than ten pounds at one time shall be regarded as a retail dealer in oleomargarine; and sections thirty-two hundred and thirty-two, thirty-two hundred and thirty-three, thirty-two hundred and thirty-four, thirty-two hundred and thirty-five, thirty-two hundred and thirty-six, thirty-two hundred and thirty-seven, thirty-two hundred and thirty-eight, thirty-two hundred and thirty-nine, thirty-two hundred and forty, thirty-two hundred and forty-one, and thirty-two hundred and forty-three of the Revised Statutes of the United States are, so far as applicable, made to extend to and include and apply to the special taxes imposed by this section, and to the persons upon whom they are imposed: *Provided*, That in case any manufacturer of oleomargarine commences business subsequent to the thirtieth day of June in any year. the special tax shall be reckoned from the first day of July in that year,-and shall be five hundred dollars.

SEC. 4. That every person who carries on the business of a manufacturer of oleomargarine without having paid the special tax therefor, as required by law, shall, besides being liable to the payment of the tax, be fined not less than one thousand and not more than five thousand dollars; and every person who carries on the business of a wholesale dealer in oleomargarine without having paid the special tax therefor, as required by law, shall, besides being liable to the payment of the tax, be fined not less than five hundred nor more than two thousand dollars; and every person who carries on the business of a retail dealer in oleomargarine without having paid the special tax therefor, as required by law, shall, besides being liable to the payment of the tax, be fined not less than fifty nor more than five hundred dollars for each and every offense.

SEC. 5. That every manufacturer of oleomargarine shall file with the collector of internal revenue of the district in which his manufactory is located such notices, inventories, and bonds, shall keep such books and render such returns of material and products, shall put up such signs and affix such number to his factory, and conduct his business under such surveillance of officers and agents as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may, by regulation, require. But the bond required of such manufacturer shall be with sureties satisfactory to the collector of internal revenue, and in a penal sum of not less than five thousand dollars; and the sum of said bond may be increased from time to time, and additional sureties required at the discretion of the collector, or under instructions of the Commissioner of Internal Revenue.

SEC. 6. That all oleomargarine shall be packed by the manufacturer thereof in firkins, tubs, or other wooden packages not before used for that purpose, each containing not less than ten pounds, and marked, stamped, and branded as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe; and all sales made by the manufacturers of oleomargarine, and wholesale dealers in oleomargarine, shall be in original stamped packages. Retail dealers in oleomargarine must sell only from original stamped packages, in quantities not exceeding ten pounds, and shall pack the oleomargarine sold by them in suitable wooden or paper packages, which shall be marked and branded as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe. Every person who knowingly sells or offers for sale, or delivers or offers to deliver, any oleomargarine in any other form than in new wooden or paper packages as above described, or who packs in any package any oleomargarine in any manner contrary to law, or who falsely brands any package or affixes a stamp on any package denoting a less amount of tax than that required by law, shall be fined for each offense not more than one thousand dollars, and be imprisoned not more than two years.

SEC. 7. That every manufacturer of oleomargarine shall securely affix, by pasting, on each package containing oleomargarine manufactured by him, a label on which shall be printed, besides the number of the manufactory and the district and State in which it is situated, these words: "Notice—The manufacturer of the oleomargarine herein contained has complied with all the requirements of law. Every person is cautioned not to use either this package or the stamp thereon again, nor to remove the contents of this package without destroying said stamp, under the penalty provided by law in such cases." Every manufacturer of oleomargarine who neglects to affix such label to any package containing oleomargarine made by him, or sold or offered for sale by or for him, and every person who removes any such label so affixed from any such package, shall be fined fifty dollars for each package in respect to which such offense is committed.

SEC. 8. That upon oleomargarine which shall be manufactured and sold, or removed for consumption or use, there shall be assessed and collected a tax of two cents per pound, to be paid by the manufacturer thereof; and any fractional part

of a pound in a package shall be taxed as a pound. The tax levied by this section shall be represented by coupon stamps; and the provisions of existing laws governing the engraving, issue, sale, accountability, effacement, and destruction of stamps relating to tobacco and snuff, as far as applicable, are hereby made to apply to stamps provided for by this section.

SEC. 9. That whenever any manufacturer of oleomargarine sells, or removes for sale or consumption, any oleomargarine upon which the tax is required to be paid by stamps, without the use of the proper stamps, it shall be the duty of the Commissioner of Internal Revenue, within a period of not more than two years after such sale or removal, upon satisfactory proof, to estimate the amount of tax which has been omitted to be paid, and to make an assessment therefor and certify the same to the collector. The tax so assessed shall be in addition to the penalties imposed by law for such sale or removal.

SEC. 10. That all oleomargarine imported from foreign countries shall, in addition to any import duty imposed on the same, pay an internal revenue tax of fifteen cents per pound, such tax to be represented by coupon stamps as in the case of oleomargarine manufactured in the United States. The stamps shall be affixed and canceled by the owner or importer of the oleomargarine while it is in the custody of the proper custom-house officers; and the oleomargarine shall not pass out of the custody of said officers until the stamps have been so affixed and canceled, but shall be put up in wooden packages, each containing not less than ten pounds, as prescribed in this act for oleomargarine manufactured in the United States, before the stamps are affixed; and the owner or importer of such oleomargarine shall be liable to all the penal provisions of this act prescribed for manufacturers of oleomargarine manufactured in the United States. Whenever it is necessary to take any oleomargarine so imported to any place other than the public stores of the United States for the purpose of affixing and canceling such stamps, the collector of customs of the port where such oleomargarine is entered shall designate a bonded warehouse to which it shall be taken, under the control of such customs officer as such collector may direct; and every officer of customs who permits any such oleomargarine to pass out of his custody or control without compliance by the owner or importer thereof with the provisions of this section relating thereto, shall be guilty of a misdemeanor, and shall be fined not less than one thousand dollars nor more than five thousand dollars, and imprisoned not less than six months nor more than three years. Every person who sells or offers for sale any imported oleomargarine, or oleomargarine purporting or claimed to have been imported, not put up in packages and stamped as provided by this act, shall be fined not less than five hundred dollars nor more than five thousand dollars, and be imprisoned not less than six months nor more than two years.

SEC. 11. That every person who knowingly purchases or receives for sale any oleomargarine which has not been branded or stamped according to law shall be liable to a penalty of fifty dollars for each such offense.

SEC. 12. That every person who knowingly purchases or receives for sale any oleomargarine from any manufacturer who has not paid the special tax shall be liable for each offense to a penalty of one hundred dollars, and to a forfeiture of all articles so purchased or received, or of the full value thereof.

SEC. 13. That whenever any stamped package containing oleomargarine is emptied, it shall be the duty of the person in whose hands the same is to destroy utterly the stamps thereon; and any person who willfully neglects or refuses so to do shall for each such offense be fined not exceeding fifty dollars, and imprisoned not less than ten days nor more than six months. And any person who fraudulently gives away or accepts from another, or who sells, buys, or uses for packing oleomargarine, any such stamped package, shall for each such offense be fined not

exceeding one hundred dollars, and be imprisoned not more than one year. Any revenue officer may destroy any emptied oleomargarine package upon which the tax-paid stamp is found.

SEC. 14. That there shall be in the office of the Commissioner of Internal Revenue an analytical chemist and a microscopist, who shall each be appointed by the Secretary of the Treasury, and shall each receive a salary of two thousand five hundred dollars per annum; and the Commissioner of Internal Revenue may, whenever in his judgment the necessities of the service so require, employ chemists and microscopists, to be paid such compensation as he may deem proper, not exceeding in the aggregate any appropriation made for that purpose. And such Commissioner is authorized to decide what substances, extracts, mixtures, or compounds which may be submitted for his inspection in contested cases are to be taxed under this act; and his decision in matters of taxation under this act shall be final. The Commissioner may also decide whether any substance made in imitation or semblance of butter, and intended for human consumption, contains ingredients deleterious to the public health; but in case of doubt or contest his decisions in this class of cases may be appealed from to a board hereby constituted for the purpose, and composed of the Surgeon-General of the Army, the Surgeon-General of the Navy, and the Commissioner of Agriculture; and the decision of this board shall be final in the premises.

SEC. 15. That all packages of oleomargarine subject to tax under this act that shall be found without stamps or marks as herein provided, and all oleomargarine intended for human consumption which contains ingredients adjudged, as hereinbefore provided, to be deleterious to the public health, shall be forfeited to the United States. Any person who shall willfully remove or deface the stamps, marks, or brands on package containing oleomargarine taxed as provided herein shall be guilty of a misdemeanor, and shall be punished by a fine of not less than one hundred dollars nor more than two thousand dollars, and by imprisonment for not less than thirty days nor more than six months.

SEC. 16. That oleomargarine may be removed from the place of manufacture for export to a foreign country without payment of tax or affixing stamps thereto, under such regulations and the filing of such bonds and other security as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe. Every person who shall export oleomargarine shall brand upon every tub, firkin, or other package containing such article the word "oleomargarine," in plain Roman letters not less than one-half inch square.

SEC. 17. That whenever any person engaged in carrying on the business of manufacturing oleomargarine defrauds, or attempts to defraud, the United States of the tax on the oleomargarine produced by him, or any part thereof, he shall forfeit the factory and manufacturing apparatus used by him, and all oleomargarine and all raw material for the production of oleomargarine found in the factory and on the factory premises, and shall be fined not less than five hundred dollars nor more than five thousand dollars, and be imprisoned not less than six months nor more than three years.

SEC. 18. That if any manufacturer of oleomargarine, any dealer therein, or any importer or exporter thereof shall knowingly or willfully omit, neglect, or refuse to do, or cause to be done, any of the things required by law in the carrying on or conducting of his business, or shall do anything by this act prohibited, if there be no specific penalty or punishment imposed by any other section of this act for the neglecting, omitting, or refusing to do, or for the doing or causing to be done, the thing required or prohibited, he shall pay a penalty of one thousand dollars; and if the person so offending be the manufacturer of or a wholesale dealer in oleomargarine, all the oleomargarine owned by him, or in which he has any interest as owner, shall be forfeited to the United States.

SEC. 19. That all fines, penalties, and forfeitures imposed by this act may be recovered in any court of competent jurisdiction.

SEC. 20. That the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may make all needful regulations for the carrying into effect of this act.

SEC. 21. That this act shall go into effect on the ninetieth day after its passage; and all wooden packages containing ten or more pounds of oleomargarine found on the premises of any dealer on or after the ninetieth day succeeding the date of the passage of this act shall be deemed to be taxable under section eight of this act, and shall be taxed, and shall have affixed thereto the stamps, marks, and brands required by this act or by regulations made pursuant to this act; and for the purposes of securing the affixing of the stamps, marks, and brands required by this act, the oleomargarine shall be regarded as having been manufactured and sold, or removed from the manufactory for consumption or use, on or after the day this act takes effect; and such stock on hand at the time of the taking effect of this act may be stamped, marked, and branded under special regulations of the Commissioner of Internal Revenue, approved by the Secretary of the Treasury; and the Commissioner of Internal Revenue may authorize the holder of such packages to mark and brand the same and to affix thereto the proper tax-paid stamps.

Approved, August 2, 1886.

The only valid objection to the unrestricted sale of oleomargarine appears to be that it is so perfect an imitation of genuine butter that ordinary purchasers are deceived and may pay double the real value for the imitation butter. There seems to be little question as to its healthfulness. It is of very much better taste and will keep very much longer than cheap butter.

In general, the laws passed in this country and in Europe regulate the sale rather than prohibit the manufacture. The poor, to whom the discovery of Megé-Mouries is a great blessing, do not complain but the producers of genuine butter complain that the imitation butter replaces the real article. Customers should complain if they are deceived and pay more than the food is worth.

Several foreign countries have enacted special laws regulating the trade in butter substitutes. Among these countries are Sweden, France, Russia, Germany, England and Denmark. Other countries, as Austria-Hungary, Belgium, Italy, Netherlands and Switzerland have general laws relating to food adulteration. I shall not here review all these laws, but will refer to the Annual Reports of the United States Commissioner of Internal Revenue for 1888 and 1889, where the full text of all such laws will be found.

In Sweden artificial butter under the "Margarine Act" may be sold, if plainly marked so that purchasers may not be deceived.

In France the sale, importation, or exportation, of all imitations of butter is forbidden, except when packages are plainly stamped "Margarine, oleomargarine, or edible fats."

Russia requires that imitation butter shall be called "margarine fat," imposes a tax on manufacturers, and requires that the margarine "shall be dyed some bright color, but in no case shall such color be yellow."

The package must also be colored and must be branded "margarine fat."

In Germany the business localities and other sale places, including market stalls where margarine is sold, must have the inscription "sale of margarine" indelibly stamped on them in a conspicuous place. By margarine, in the sense of this law, is to be understood all preparations similar to milk butter whose fatty substances are not exclusively derived from milk. The packages containing margarine must be plainly marked.

Great Britain defines artificial butter as "margarine" and requires packages, whether opened or closed, to be plainly branded on the top, bottom, and sides in printed capital letters not less than three-fourths of an inch square.

Denmark also requires articles resembling butter, not produced entirely from milk, to be plainly branded "margarine," and every shop where it is sold must display a sign "Margarine for sale here." The selling of margarine on the market places and in shops is prohibited. The manufacturing, importing, exporting, or selling of margarine containing more than 50 per cent of butter is prohibited.

In Holland the general laws prohibit the sale of any food product under false representations and with the knowledge that it was not what the purchaser supposed he was buying.

In Switzerland some of the cantons have enacted laws which prevent the sale of artificial butter, except as such.

IV.—CHEESE.

In some European countries cheese is not eaten as a luxury, but as a substitute for meat. While cheese is usually made from cow's milk, great quantities of goat's milk are used in Europe. In Arabia camel's milk and mare's milk are also made into cheese. The soft cheeses made in France are as delicate as butter. The United States produces about 450,000,000 pounds of cheese annually and exports about 90,000,000 pounds, almost wholly to Great Britain and Canada.

France makes 225,000,000 pounds of cheese and exports about 9,000,000, and imports chiefly from Switzerland and the Netherlands 37,000,000 pounds.

In 1888 Great Britain imported 215,000,000 pounds of cheese, valued at $22,910,000, purchased principally from the United States and Canada.

Switzerland exports about 440,000,000 pounds of cheese.

CHEESE-MAKING IN FRANCE.

Since 1878 much progress has been made in the manufacture of cheese, and in France, especially, the improvement has been great. There is a steady increase in the exports of fat or rich cheese, but a decrease in dry cheese.

The north of France produces the cheese of Maroïlles, Compiègne, and twenty other varieties. In the south are the cheeses of the Pyrénées, similar to Gruyère cheese, the Roquefort cheese, so renowned throughout the world, the cheeses of Cantal, etc. In the east of France are made the cheeses known as Gérardmer, Munster, Brie, Coulommiers, and the Gruyères. In the west are Normandy and Brittany, famous for dairy products. Charentes produces Holland cheeses for exportation. In the department of Lower Seine are made the Gournay, Neuchatel, Uralakoff, and Petits Suisse cheeses, largely exported to Germany and Russia.

From seventy-five to eighty varieties of cheeses are made in France. The annual production is about 250,000,000 pounds. The importation in 1887 for consumption was 37,693,977 pounds, coming chiefly from Holland and Switzerland, and the exportation of fresh made cheese was 9,750,492 pounds.

The French classify cheese as follows:

Soft Cheese.		Hard Cheese (pressed and salted).	
Fresh.	Ripened.	Raw.	Cooked.
Maigre à la pie.	Brie.	Gex.	Port Salut.
Blanc, à la crème.	Camembert.	Roquefort.	Gautrais.
Suisse, double crème.	Marolles.	Sassenage.	Providence.
Demi-sel.	Livarot.	Cantal.	Gruyère.
Petit carré.	Neuchatel.	Mont Cénis.	*Foreign.*
Malakoff	Pont-l'Évêque.	Septmontel.	Gruyère, Suisse.
Boudon.	Saint Marcellin.	Hollande.	Emmenthal.
Gournay.	Epoisses.	*Foreign.*	Reggian.
Coulommiers.	Coulommiers.	Hollandais Tete de maure.	Parmesan.
Mont d'or, etc.	Mont d'Or.	Hollandais, Leyden.	Cacciocavallo.
	Géromé.	Hollandais, Etuvé.	Mysost, etc.
	Foreign.	Chester.	
	Romatour.	Stilton.	
	Limbourg.	Cheddar.	
	Herré.	Provole,	
	Munster.	Schabzieger.	
	Gorgonzole, etc.		

The two principal classes of cheese, as seen above, are soft and hard.

SOFT CHEESES.

Camembert.—This cheese holds the first rank among soft cheeses. Its manufacture, which requires exceptional care, is carried on only in certain conditions of the temperature, and presents more difficulties than other cheeses.

It is said to have been first made in 1791 by Madame Harel in the Commune of Camembert, whence its name. This cheese is in small disks about 1½ inches thick and 4 inches in diameter. Milk not creamed makes the best cheese. After coagulating, the milk is put

in forms, and on the following day the cheese is salted on both sides and left to drain for one or two days, when it is put to dry for 20 or 25 days, the air in the drying room being frequently renewed. The ripening takes three or four weeks.

The annual production of Camembert cheese is valued at about $200,000.

Livarot.—The Livarot cheese takes its name from the principal place in the Canton of Calvados. It is made of skim milk. The cheeses are cylindrical, measuring about 6 inches in height and diameter. They are made both fresh and salt. The ripening cellar is kept closed without renewing the air. The walls are made of material to resist the action of the ammonia gas liberated during fermentation, and which gives the cheese its characteristic flavor. About 4,000,000 of these cheeses are made each year, valued at $400,000.

Mont d'Or.—Formerly in the vicinity of Lyon they made a cheese of very delicate taste from goat's milk, but now the Mont d'Or cheese is made almost exclusively from cow's milk. The fine yellow color and the special flavor of the genuine Mont d'Or cheese results from the white wine used in the ripening process. The cheeses are soaked in wine and pressed between two plates that are turned from time to time. They are exposed to the fresh air for one or two months. Aromatic herbs are sometimes used in flavoring. This cheese is one of the most important varieties. Its shape is the same as the Camembert, and in price is often considerably dearer than that kind.

Rollot.—This cheese takes its name from a commune in the department of Somme. When carefully made from unskimmed milk it is an excellent quality, and is eaten chiefly in the autumn months.

Coulommiers.—These little cheeses, about 1½ inches thick and 5 inches in diameter, are made chiefly in Brie, and are eaten either fresh or ripened. They are made from unskimmed milk, to which is sometimes added cream raised on another milk.

Brie.—The cheeses known under the name Brie are of three qualities, made either from unskimmed milk or from milk partly or wholly deprived of cream. They are made in thin, flat form, from 12 to 15 inches in diameter, and about 1½ inches thick.

HARD CHEESES.

Roquefort.—This famous cheese of ancient origin is made in the department of Aveyron. About 800,000 goats are kept in that district, and 500,000 of them supply milk to the cheese-makers. Good quality Roquefort is fine, slightly sharp to the taste, and is marbled with blue veins.

Milk fresh from the goats, after standing three-quarters of an hour, is filtered, warmed, and put in earthern jars. When the cream has raised part of it is skimmed off to make butter. In the morning

the unskimmed milk is mixed with that of the day before. Two teaspoonfuls of rennet from a kid will coagulate about 45 quarts of milk. With a ladle the curd is separated from the whey and kneaded with the hands. The curd is then molded in terre-cotta forms about 4 inches deep and 9 inches in diameter, the bottom and sides pierced with holes. The form holds about 6½ pounds of curd, which produces a cheese weighing 5½ pounds. The blue veins in this cheese are produced by sprinkling the forms with blue mold from moldy rye bread. After being pressed for 10 or 12 hours, the cheeses are dried in bands of iron for 10 or 12 days, and are then taken to the caves to mature.

The extensive natural grottos in the mountain sides at Roquefort are peculiarly suited to cheese-curing. Through the crevasses in the rocks flows a current of cold air that keeps the temperature low at all seasons. When the thermometer in the open air stands at 84°, it reaches only 40° in the caves.

The managers of the caves, called the Sociétié des caves et des Producteurs réunis de Roquefort, receive the cheeses from the farmers, mark them and store them until matured.

In 1877 the production of cheese at Roquefort was 8,800,000 pounds, and in 1888 it was 11,000,000 pounds, valued at $300,000.

The production at various periods from 1800 to 1888 has been as follows:

	Pounds.		Pounds.
1800	555,000	1860	5,940,000
1820	660,000	1876	7,150,000
1840	1,650,000	1877	8,800,000
1850	3,080,000	1888	11,000,000

The joint-stock company above mentioned has organized several central cheese factories, to which the farmers bring their milk. The factories are fully equipped with improved apparatus, and the work of the first few years has shown that the quality of cheese is better than when the milk was worked in small quantities by numerous farmers throughout the country, and the product of a goat now averages 30 cents more than under the old system.

Gruyère.—This cheese is of Swiss origin, but is now made in parts of France adjacent to the Alps, and even in other countries. It takes its name from the little village of Gruyère, not far from Fribourg in Switzerland. It is a type of cooked cheese. The curd before being molded is cooked, which gives it a consistence and some special qualities. There are three grades, the principal difference being that the milk is either pure, partly or wholly skimmed.

They are made in large loaves, weighing sometimes nearly 300 pounds. When of good quality, the "eyes" or holes in the cheese are few and measure one-fourth to five-sixteenths of an inch in diameter; a piece of it crumbles easily in the fingers and leaves a slightly salt taste in the mouth.

High up on the mountains in Switzerland and in France the peasants, in their picturesque chalets, employ much of their time in making Gruyère cheese, while in the valleys the work is generally carried on in local factories, to which neighboring farmers carry their milk.

ITALIAN CHEESES.

Italy is famous for good qualities of butter and cheese. The United States imports upward of a million pounds of Italian cheese each year, and European countries are large purchasers of both butter and cheese from Italy. The Piedmontese make several kinds of cheese, of which the best are *gruyera, fontina, rubiole, graua,* and *stracchino. Rubiole* are small sheep's milk cheeses. The best dairying districts of Lombardy are Lodi, Pavia, and Milan, which produce annually 24,000,000 pounds of butter, and 60,500,000 pounds of cheese. The Macerata region, though small, produces each year about 150,000 pounds of cheese that is very highly esteemed in London and Paris. Its excellence is due to the healthy and aromatic plants that abound in the Marcerata hills. From sheep's milk, the Spoletese make about 777,000 pounds of cheese each year. The sweet cheeses called marzoline, from the southern Adriatic provinces, are very delicious. The following description of the Italian method of making Gorgonzola cheese is condensed from a report by Mr. T. C. T. Train, United States Consul at Milan.*

In making Piedmontese cheese the milk is used when tepid. It is mixed and shaken in whey, which curdles it in one-quarter of an hour. The curd is shaken for drainage, and, when dry, pressed in a form. Sometimes this cheese is made of partly skimmed milk.

Stracchino, or Gorgonzola, is made of milk containing the buttery parts. The Berganese herdsmen feed their cattle during September and October on the luxuriant vegetation about Gorgonzola. The peasants buy the milk from the herdsmen at this period and make the cheese in their homes. The milk while warm from the cow is curdled with calf rennet. In about 15 minutes, when the milk is çoagulated and the whey separated, the curd is hung in hemp cloths to drain. As cows are milked twice daily, the foregoing operation is done both morning and evening. The morning-drained curd, inclosed in light flexible wooden bands, covered on their inside surface with hemp cloth, is placed on an inclined board strewn with rye chaff. Being of two milkings, the curd is partly warm, partly cold. and, though mixed, care is taken to form the upper and lower strata of the warm, because it is cementitious. As hot and cold curd never perfectly unite, minute interstices remain in the cheese, in which, while maturing, green mold, known as "parsley," forms and gives the *stracchino* the delicious taste for which it is famous. The curd is further drained during the first day of the process by two or three turnings. On the following morning, when of some consistency, the cloth being removed, its value is determined by weighing. After three or four days fermentation begins, and the wooden bands are removed. It is then, once daily for 8 or 10 days, alternately salted on its upper and lower side, 4 ounces of pulverized salt being, on an average, used per form, or 33 pounds.

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* United States Consular Reports; Cattle and Dairy Farming, p. 678.

The Gorgonzolese adopted some years ago the process of quickly turning or pressing the cheese against a salt-covered surface, thus insuring more uniformity and a better crust. The color changes in a month to pinkish white, if good; to black, if bad. When black, the crust is bad and the cheese perishable in summer. If the crust is sufficiently hard, the shade is improved by one or two dippings in salt water. The time of maturity depends upon the temperature, manner of making, and quality of milk. It usually begins to ripen in April and continues till September. One hundred quarts of milk make about 25 pounds of this cheese.

In the report above referred to, Consul Train describes the process of making *Bellunese, formaggio di grana, caciocavallo, proratura,* and other kinds of Italian cheese.

On the plains north and east of the province of Naples, in the region called "Terra di Lavoro," once called "Campagna," there roams in a semi-wild state about 12,000 cattle of the buffalo race, the origin of which is not known. The cheeses made from the milk of the buffalo cows are called "latticini." They are close and heavy in consistency, sweet, and are used entirely for home consumption.

Great quantities of cheese are made with the milk of goats and sheep, as well as from cow's milk.

In Lombardy, especially at Crema, Codogno, and Lodi, they make the Parmesan cheese, which is much esteemed. It has an agreeable taste peculiar to itself, and will keep good for a long time, and seldom acquires a rancid or putrid odor. It is made from milk partly skimmed. In preparing it, the milk is heated in copper boilers and is coagulated with dry rennet. When the curd has formed, some powdered saffron is added. These cheeses are well salted, but are not pressed. There is a large export trade in Parmesan cheese to the East, and to Africa and South America.

ROUMANIA CHEESES.

Every year, towards the 15th of July, the lambs are separated from the sheep, and the people either drink the milk fresh or use it for making varieties of cheese named *cache, brandza,* and *ourda.*

In August and September these cheeses are put in caves, in alternate layers of coarse salt, and milk then poured over them. In this way they ferment during the first winter months, and are not eaten until the beginning of spring.

In the mountainous regions a dry and sharp cheese is made, called the *brandza de burduf.* In certain localities they add essence to the cheese, and then inclose it in a tubular case made from the bark of the pitch-pine tree. This variety is called the *brandza de cochulets.* They also make the *cachecaval*, a round cheese, more or less hard, of fine flavor and very high priced. In the mountains near Gogin they prepare the dried and smoked cheeses like those of Italy. In the districts of Argés and Muscel they make a cheese which is very much like the gruyere. Cheese made in the mountains is considered better than that made in the plains.

The milk left in making cheese is collected and cooked and from it they extract *ourda*, which is eaten fresh or salted, and which is preserved in earthen bottles. The milk curd made in August and eaten all winter is an important article of food with these people.

CHEESE-MAKING IN SWITZERLAND.

About five-eighths of the cheese imported into the United States comes from Switzerland. The quantity purchased in 1888 was 5,597,000 pounds.

The average annual exports of cheese from Switzerland aggregate 440,000,000 pounds sent throughout the world.

Swiss cheeses are classified about the same as the French varieties, and are as follows :

Name.	Consistency.	Fatty matter.	Coagulation.
Emmenthal	Firm.	Gras.	By rennet.
Gruyère	do.	Mi-gras.	do.
Spalen, old	Hard.	do.	do.
Spalen, new	Firm.	do.	do.
Urseren	do.	Gras.	do.
Formaggio della paglia	Soft.	do.	do.
Battelmatt	Firm.	do.	do.
Appenzell	do.	Maigre.	do.
Gessenay	Hard.	Gras.	do.
Cristallina	Firm.	do.	do.
Vacherin	Soft.	do.	do.
Bellelay	Firm.	do.	do.
Valais	Hard.	do.	do.
Praettigan	Firm.	Maigre.	do.
Vaud	Hard.	do.	do.
Tomme	Soft.	Gras.	do.
Schnabziger			By sour milk.
Blocler	Firm.	Maigre.	do.

Fromage gras is cheese from unskimmed milk; maigre, from skimmed milk; and mi-gras; from partly skimmed milk.

With the exception of *vacherin*, which originated in France, and the *urseren*, from Italy, and a few imitations of foreign styles, like the *limbourg*, all the cheese names are native and peculiar to Switzerland.

The *Emmenthal* is the best and most abundant cheese. It is round, 30 to 40 inches in diameter and 4 to 6 inches thick, and weighs from 100 to 200 pounds. It was first made in the valley of the Emme, near Berne, but it is now made in great quantities in the neighboring cantons and also in Bavaria, Russia, North Germany, and North and South America. It is known in the United States as *schweizer käse*. It is a rich cheese and very nutritive. In winter a good deal is made from partly skimmed milk.

The *Gruyère* cheese is next in importance to the *Emmenthal.* It takes its name from the village Gruyère, near Fribourg. This is also a round cheese, 25 to 30 inches in diameter, and 3½ to 5 inches thick, being smaller than the *Emmenthal.* It is classed as mi-gras, being made from milk partly skimmed.

The *Spalen* is also a mi-gras cheese and is still smaller than the Gruyère, being from 17 to 22 inches in diameter, and 3 to 4 inches thick, weighing 40 to 50 pounds. The Italians import this cheese, and use it grated with macaroni, rice, etc.

The *Appenzell* cheese differs much from other varieties. The curd is triturated in a brazier, molded without pressure or salting, and finally treated with a brine of water, wine, lees of white wine, pepper and salt, which gives it a pungent odor, and flavor. This cheese is 10 to 12 inches in diameter, 5 to 6 inches thick, and weighs 15 to 17 pounds.

The *Schnabziger,* or green cheese, is known in the United States as sago cheese or sapsago. It has been made for many centuries in the canton of Glaris. Its peculiarity is due partly to the method of coagulation by age instead of by rennet, and partly to treatment by the zigerlee, *Melilotus cœrulea,* a plant grown for the purpose in Schwyz. It is sent all over the world.

The *Gessenay* is made in the canton of Berne, and is a cream cheese of fine aromatic flavor, very hard, and will keep well for years. A similar cheese is made in the canton of Valais.

The only soft cheese of large size is the *Vacherin.* There are two kinds, one made in Gruyère, the other in the valley of the Jura.

CHEESE IN BELGIUM.

Among the different sorts of cheese made in Belgium two kinds are of primary importance, the cheeses of Brussels and those of Herve. The Brussels cheeses are consumed in the country, especially in the province of Antwerp. Their form is round, about 15 to 20 centimetres in diameter, and 2 to 3 centimetres in thickness. They are eaten by the poorer classes because of their low price. They are strong in taste and will keep for a long time.

The cheeses of Herve, made in the province of Liege, are much sought after for consumption at home and for exportation, chiefly to Switzerland and Lorraine. The quantity made is enormous, all the farmers making them, some as many as two to three hundred a week. These cheeses are cubic or rectangular in form. The best quality is made of pure milk and a second grade of skimmed milk. They weigh from 1,200 down to 400 grammes or less.

CHEESE IN THE UNITED STATES.

Most of the cheeses made in the United States belong to the variety known as "American cheddar." These are 18 to 20 inches in diame-

ter and about 6 inches thick. The "Young America" cheeses are much smaller in size.

Fancy cheeses, such as Limburger, Stilton, Edam, Pineapple, and Neuchatel are made in some localities.

Imitation cheese, or lard cheese, is made to some extent in the United States and Canada from skimmed milk and lard. In 1873 a patent for a process of preparing this product was issued to H. O. Freeman, and one to William Cooley in 1881. An emulsion of lard is made by bringing together in a disintegrator lard and skimmed milk, both previously heated to 140° F. in steam-jacketed tanks. The emulsion consists of from two to three parts of milk to one of lard. In making the cheese, a quantity of this emulsion containing about 80 pounds of lard is added to 6,000 pounds of skimmed milk and about 600 pounds of buttermilk in the cheese vat, and the lard that does not remain incorporated with the milk—usually about 10 pounds—is carefully skimmed off. These quantities of the materials yield 500 to 600 pounds of cheese, containing about 70 pounds of lard, or about 14 per cent; about half of the fat removed in the skimming of the milk is replaced by lard.*

V.—EGGS OF BIRDS, REPTILES, ETC.

Eggs are of universal use as food throughout the world, being a very valuable food. While the eggs of all birds may be used as food, there is a great difference in the flavor of them, depending upon the feeding habits of the bird. The eggs of the seagull are stronger than those of the duck, and the latter are not of such sweet and rich flavor as eggs of the domestic fowl or plover.

There is an immense commerce in hen's eggs. Great Britain imports annually about 1,000,000,000 eggs, valued at $14,000,000.

France exports about 400,000,000 eggs, and the annual production is estimated to be 10,000,000,000. In the Parisian market, eggs are sold either by weight or by count, each kilogram calculated to equal 20 eggs. They are marketed in baskets of 1,000 eggs each. In the United States, the annual production is upwards of 9,000,000,000 eggs.

Turtle's eggs are largely consumed for food, especially in the West Indies, South America and India. They are about the size of a pigeon's egg and have a soft shell. Indians in Brazil eat sometimes twenty or thirty of these at a meal. The common method of preserving these is putting them in brine or soaking them in wet sand, the yolks having been first broken by shaking the eggs.

Eggs of alligators, lizards, and snakes are used by the natives of some countries as food.

Fish eggs, or roe, are extensively used as food. Russian caviare is made from the eggs of the sturgeon. Botargo is made on the

*Caldwell: Second Annual Report, New York State Board of Health.

Mediterranean coast from the eggs of the mullet, which are salted, crushed, reduced to a paste, and dried in the sun.

In Siam, in Egypt, and in Mexico the eggs of certain insects are used as food.

A good method of preserving eggs in a fresh state for an indefinite period is by the exclusion of air and moisture and the application of an antiseptic. The eggs as taken from the nest are coated with a compound of butter (or other sweet animal fat) containing 2 to 3 per cent of salicylic acid, applied by a little wool. They are then packed in dry sawdust and allowed to cool perfectly.

Concerning the American methods of preserving eggs and packing them for shipment, I can not do better than quote the instructions issued by the National Butter, Cheese, and Egg Association of the United States.

Eggs, especially in summer, should be not only sound but fresh-laid. Stale eggs, though apparently sound, are sure to reach market in bad order, or will change so rapidly that dealers lose money on them. Always ship at once while fresh. Use strong, stiff barrels. For packing use fine, kiln-dried cut straw or wheat chaff. Some Canadian packers use dry oat hulls, which answer a good purpose. Never use oat or buckwheat chaff, and never use new oats, straw, or chaff, as they sweat and rot the eggs in a short time. Place first a little long, soft straw or hay, 2 or 3 inches in thickness, evenly over the bottom of the barrel, then about the same depth of packing, then a layer of eggs, laid upon the sides, evenly imbedded in the packing, with the ends toward the barrel, about 1 inch from the staves. Cover the layer with three-fourths or 1 inch of packing, rubbing it well in between the eggs with the hand. Cover the last layer with about 3 inches of packing, and then the same quantity of long straw or hay as at the bottom, filling so high that the head must be pressed in by a lever or other mechanical power, thus holding the contents so firmly that they can not shift or loosen in the barrel. In winter, to guard against frost, use more packing, leaving the eggs farther from the sides of the package. One of the chief causes of failure in packing eggs is using too little packing at the top, bottom, and sides of the barrel. Do not crowd too many into the package, and never let the eggs touch each other in the layers. For an ordinary flour barrel seventy dozen are quite sufficient. Put about four and one-half dozen in the first layer, and increase one-half dozen to the layer up to six and one-half dozen in the two middle layers; then decrease at the same rate. It is well to shake the barrel gently after each layer is put in, first placing a light follower upon the layer. The count should be carefully made and honestly marked on the barrels.

To make pickle use strictly pure stone lime, fine clean salt, and pure water in the following proportions: Two quarts of salt, sixty to sixty-five gallons of water, and one bushel of lime. The stronger the limewater, free from sediment, the better. Slack the lime with a portion of the water, then add the balance of the water and salt. Stir well three or four times at intervals, and then let stand until well settled and cold. Either dip or draw off the clear pickle into the cask or vat in which it is intended to preserve the eggs. When the cask or vat is filled to a depth of 15 or 18 inches put in eggs about 1 foot deep, spread over them some pickle that is a little milky in appearance, made so by stirring up some of the very light lime particles that settle last, and continue doing this as each foot of eggs is added. When the eggs are within about 4 inches of the top of the cask or vat cover them with factory cloth and spread on 2 or 3 inches of the lime that settles in making the pickle. It is of the greatest importance that the pickle be kept continually up over the lime.

For putting the eggs into the pickle it will be convenient to have a tin basin, punched quite full of inch holes, and large enough to hold six or eight dozen eggs. The edges of the basin should be covered with leather and it should have a handle about 3 feet long. Fill the basin with eggs, put both under the pickle, and turn the eggs out; they will go to the bottom without breaking. When the time comes to market the eggs they must be taken out of the pickle, cleaned, dried, and packed.

To clean them, secure half of a molasses hogshead, or something like it, filling the same about half full of water. Have a sufficient number of crates to hold twenty to twenty-five dozen eggs, made of slats, placed about three-fourths of an inch apart. Sink one of the crates in the half hogshead, take the basin used to put the eggs into the pickle, dip the eggs out, and turn them into this crate. When full rinse the eggs by raising it up and down in the water, and if necessary to properly clean them set the crate up and douse water over the eggs; then, if any eggs are found when packing from which the lime has not been fully removed they should be laid out and all the lime cleansed off when packing.

When the eggs are carefully washed, as before described, they can be set up or out in a suitable place to dry in the crates. They should dry quickly and be packed as soon as dry. In packing the same rules should be observed as in packing fresh eggs. Brick vats, built in a cellar around the walls, with about half their depth below the cellar surface, about 4 or 5 feet deep, 6 feet long, and 4 feet wide, are usually considered best for preserving eggs, although many use and prefer large tubs made of wood. When wooden vats are used they are best made of spruce, though pine answers a good purpose. Oak should never be used, as it stains the eggs. The place in which the vats are built or the tubs kept should be clean and sweet and at a low temperature, the lower the better, but above the freezing point.

VI.—ANIMAL AND VEGETABLE OILS AND FATS.

ANIMAL COMESTIBLE OILS AND FATS.

The natives of very cold climates rely on vegetable fats and oils to supply necessary warmth to their bodies. Whale and seal blubber and oil are thus eaten by the Eskimos. On the other hand, the oil of the dugong is used in some parts of Australia as a substitute for butter, both for food and for cooking, and in other countries a similar use is made of other animal oils.

There are numerous animal and vegetable fats and oils used as medicine or for food. The exhibit in class 69 includes only those valuable as food or used in cooking. The most important of animal fats and oils are butter and lard.

Oil made from the yolks of eggs is considered superior to olive oil for cooking purposes. No great quantity, however, enters into commerce for this use.

Ghee, or clarified butter, chiefly made from buffalo milk, is universally employed in domestic cooking in India.

Ostrich oil is used by the Arabs for food and medicine.

The South American Indians use pigeon grease or oil as a substitute for butter.

Sturgeon oil is used in packing caviare.

Turtle butter or oil made from the eggs and fat of turtles in Brazil and the South African islands is used for food, medicine, and lighting. About 10,000 jars are annually made in Brazil.

LARD.

The fat of the pig freed from its cellular tissue is known as "lard."

The United States is doubtless the largest producer of lard; the yield in 1888 was 600,000,000 pounds, of which amount about one-half was exported.

Russia, Hungary, and Servia are the most important lard-producing countries in Europe. Ireland produces a large quantity. Hungarian lard is supplied to the whole continent of Europe.

French manufacturers exhibited lard of very superior quality, which compared well with the exhibits of the pork-packers of Chicago.

Concerning the methods and importance of the lard industry in the United States, I quote fully from the excellent report on "Lard and Lard Adulterations" by Dr. H. W. Wiley, chemist of the Department of Agriculture:

(a) *Lard* is a term applied to the fat of the slaughtered hog, separated from the other tissues of the animal by the aid of heat.

In the crude state it is composed chiefly of the glycerides of the fatty acids, oleic and stearic or palmitic, with small portions of the connective tissues, animal gelatin, and other organic matters.

(b) *Kinds of lard.*—According to the parts of the fat used and the methods of rendering it lard is divided into several classes. According to methods of rendering, lard is classified as kettle and steam. From material used the following classification may be made:

(c) *Neutral lard.*—Neutral lard is composed of the fats derived from the leaf of the slaughtered animal, taken in a perfectly fresh state. The leaf is either chilled in a cold atmosphere or treated with cold water to remove the animal heat. It is then reduced to a pulp in a grinder and passed at once to the rendering kettle. The fat is rendered at a temperature 105° to 120° F. (40°–50° C.). Only a part of the lard is separated at this temperature and the rest is sent to other rendering tanks to be made into another kind of product. The lard obtained as above is washed in a melted state with water containing a trace of sodium carbonate, sodium chloride, or a dilute acid. The lard thus formed is almost neutral, containing not to exceed 25 per cent free acid; but it may contain a considerable quantity of water and some salt. This neutral lard is used almost exclusively for making butterine (oleomargarine).

(d) *Leaf lard.*—The residue unrendered in the above process is subjected to steam heat under pressure and the fat thus obtained is called leaf lard. Formerly this was the only kind of lard recognized in the Chicago Board of Trade, and was then made of the whole leaf.

(e) *Choice kettle-rendered lard; choice lard.*—The quantity of lard required for butterine does not include all of the leaf produced. The remaining portions of the leaf, together with the fat cut from the backs, are rendered in steam-jacketed open kettles and produce a choice variety of lard known as "kettle rendered." The hide is removed from the back fat before rendering, and both leaf and back fat are passed through a pulping machine before they enter the kettle. Choice lard is thus defined by the regulations of the Chicago Board of Trade:

"*Choice lard.*—Choice lard to be made from leaf and trimmings only, either steam or kettle rendered, the manner of rendering to be branded on each tierce."

(f) *Prime steam lard.*—The prime steam lard of commerce is made as follows: The whole head of the hog, after the removal of the jowl, is used for rendering.

The heads are placed in the bottom of the rendering tank. The fat is pulled off of the small intestines and also placed in the tank. Any fat that may be attached to the heart of the animal is also used. In houses where kettle-rendered lard is not made the back fat and trimmings are also used. When there is no demand for leaf lard the leaf is also put into the rendering tank with the other portions of the body mentioned. It is thus seen that prime steam lard may be taken to represent the fat of the whole animal, or only portions thereof. The quantity of fat afforded by each animal varies with the market to which the meat is to be sent. A hog trimmed for the domestic market will give an average of about 40 pounds, while from one destined for the English market only about 20 pounds of lard will be made. Prime steam lard is thus defined by the Chicago Board of Trade:

"*Prime steam lard.*—Standard prime steam lard shall be solely the product of the trimmings and other fat parts of hogs, rendered in tanks by the direct application of steam, and without subsequent change in grain or character by the use of agitators or other machinery, except as such change may unavoidably come from transportation. It shall have proper color, flavor, and soundness for keeping, and no material which has been salted shall be included. The name and location of the renderer and the grade of the lard shall be plainly branded on each package at the time of packing."

This lard is passed solely on inspection, the inspector having no authority to supervise rendering establishments in order to secure a proper control of the kettles. According to the printed regulations, any part of the hog containing fat can be legally used.

Since much uncertainty exists in regard to the disposition which is made of the guts of the hogs I have had the subject carefully investigated. Following are the results of the study:

(*g*) *Guts.*—The definition of the term as used by hog packers is: Everything inside of a hog except the lungs and heart, or, in other words, the abdominal viscera complete. The material is handled as follows:

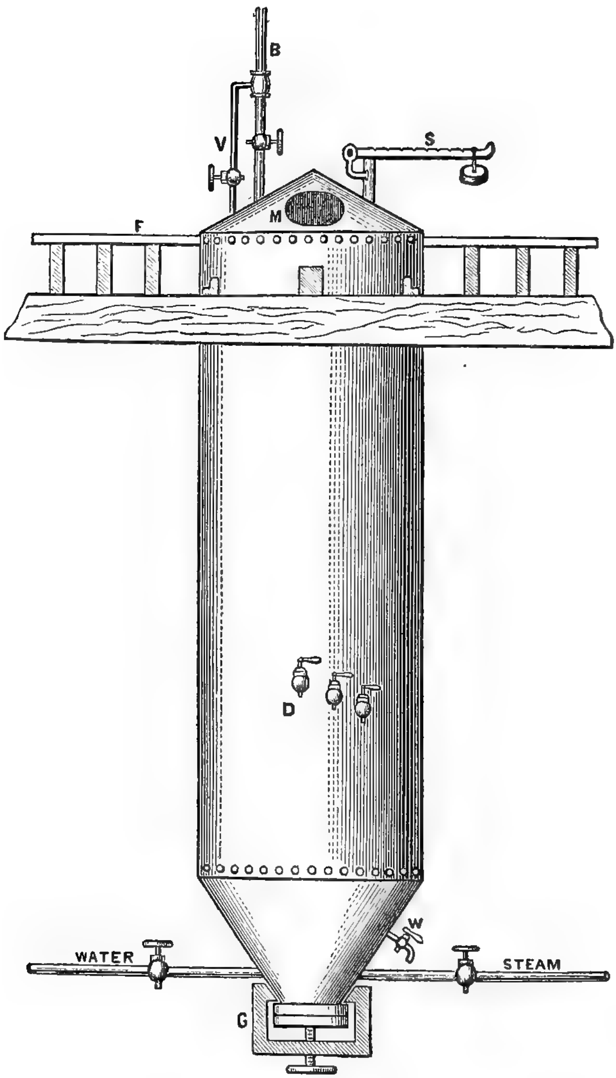
When the hog is split open the viscera are separated by cutting out the portion of flesh surrounding the anus and taking a strip containing the external urinogenerative organs. The whole viscera are thrown on a table and divided as follows: The heart is thrown to one side and the fatty portion trimmed off for lard. The rest goes into the offal tank or sausage. The lungs and liver go into the offal tank (or sausage). The rectum and large intestines are pulled from the intestinal fat and peritoneum and, along with the adhering flesh and genitourinary organs, sent to the frimmer. All flesh and the above-mentioned organs are trimmed off and the intestine proper is used for sausage casings. The trimmings, including the genito-urinary organs, are washed and dumped into the rendering tank. The small intestine is also pulled from the fatty membrane surrounding it and saved for sausage casings. The remaining material, consisting of the peritoneum, diaphragm, stomach, and adhering membranes, together with the intestinal fat, constitute the "guts" which are seen undergoing the process of washing, which is usually conducted in three or four different tanks. As the "guts" pass into the first tank the stomach and peritoneum are split open and also any portion of the intestines which sometimes adhere to the peritoneum. After receiving a rough wash they are passed from tank to tank, when, after the third or fourth wash, they are ready for the rendering tank. The omentum fat is cut from the kidneys, and the kidneys with a little adhering fat go into the rendering tank. Spleen and pancreas go into the rendering tanks, as do also the trachea, vocal chords, and esophagus.

To sum up, it is safe to say that everything goes into the rendering tank, with the following exceptions:

(1) The intestines proper, which are saved for sausage casings.

(2) The liver and lungs.

(3) That part of the heart free from fat.



LARD-RENDERING APPARATUS.

I have been told that in killing small hogs, and also when there is small demand for sausage casings, it is frequently the practice to split the intestines, so as to save expense of pulling from the fat, and after washing, fat and all go into the tank. Of course it will often happen that the intestines break off and portions adhere to the enveloping tissue, and consequently get into the tank after washing.

It is a commercial fact that sausage casings are worth more than the small amount of adhering fat, and consequently packers will save them. Small hogs produce small casings difficult to pull, and it is reasonable to believe that they will be handled in the simpler manner. They break so easily that they are hardly worth saving separately. It is stated by lard manufacturers that the grease made from the parts of the intestines mentioned above is used for the manufacture of lard oil and soap, and does not enter into the lard of commerce.

(*h*) *Butchers' lard.*—The small quantities of lard made by butchers are usually "kettle rendered," after the manner practiced by small farmers in making lard for home consumption. Often the scraps are saved up for a considerable length of time by the butchers before rendering, and that is likely to increase the free acid present. This lard is also frequently dark colored, and contains a considerable quantity of glue. In New York this lard is known as "New York City Lard."

In Plate LI is represented the type of apparatus used for rendering lard, etc., under pressure. The rendering vessel is made of boiler iron or steel, and varies in size according to the magnitude of the establishment. A very common size is 10 to 12 feet in length and 3 to 5 feet in diameter. The heads, scraps, and other materials are put in at M. When the tank is full, M is closed. Steam is admitted through the pipe thus marked, and condensed water drawn off through the water pipe. Through the cocks at D the depth of lard in the tank can be determined and the lard drawn off. When the process is finished and the lard drawn off, the bottom G is opened and the "tankage" withdrawn and dried for fertilizing purposes.

(B) Other hog-fat products.

There are many other hog-fat products not used in the manufacture of lard or compound lard, a description of which, however, may prove useful here.

(*a*) *White grease.*—This grease is made chiefly from hogs which die in transit, by being smothered or frozen. Formerly it was also made from animals dead of disease; but this product has of late been diminished on account of certain State laws requiring the carcasses of hogs which have died of cholera to be buried. This grease is made from the whole animal with the exception of the intestines. The latter are rendered separately and make "brown grease." The rendering is done in closed tanks at a high pressure. The residue is used in the manufacture of fertilizer. White and brown grease are used chiefly in the manufacture of low-grade lard oils and soap.

(*b*) *Yellow grease.*—Yellow grease is made by packers. All the refuse materials of the packing-houses go into the yellow-grease tank, together with any hogs which may die on the packers' hands. Yellow grease is intermediate in value between white and brown. It is used for the same purposes.

(*c*) *Pigs'-foot grease.*—This grease is obtained chiefly from the glue factories, and is used for making lard oils and soap.

(2) STEARINS.

The stearins are the more solid portions of the animal fats remaining after the more fluid portions have been removed by pressure. The stearins used in the manufacture of compound lard are lard stearin, derived from lard, and oleo-stearin, derived from a certain quality of beef tallow. Cotton-oil stearin is used chiefly in the manufacture of butterine.

(A) Lard stearin.

The lard stearin used in compound lard is made as follows:

The prime steam lard, if properly crystallized and of the right temperature (from 45° to 55° F., winter; 55° to 65°, summer), is sent at once to the presses. If not properly grained, it is melted and kept in a crystallizing room at 50° to 60° F., until the proper grain is formed. The lard is then wrapped in cakes with cloth, each cake containing 10 to 20 pounds. The cakes are then placed in a large press, with suitable septa to facilitate the egress of the oil. These presses are sometimes 40 to 50 feet in length, and when first filled 12 to 18 feet high. The pressure is applied very gradually at first by means of a lever working a capstan, about which the chain is wrapped, attached to the upper movable part of the press.

The oil expressed, prime or extra lard oil, is used for illuminating and lubricating purposes. The resulting stearin is used for making compound lard and is worth more than the lard. It has about .5 per cent free fatty acid (less than the lard oil), and crystallizes in long needles, making the texture tough.

(B) Oleo-stearin.

This product is made chiefly from the caul fat of beeves. This fat is rendered in open kettles at a low temperature. The resulting tallow is placed in cars in a granulating room, where it is allowed to remain for thirty-six to forty-eight hours at a temperature 80° to 90° F. The contents of the cars are then mixed and placed on a revolving table, where they are made into cakes. These are wrapped with strong cotton cloth and placed in a strong press, where a gradual pressure at 90° F., becoming very strong at the end, is applied for one or two hours. The expressed oil, known as oleo-oil, is used in the manufacture of butterine. The stearin is removed from the press as white hard cakes, and is used for adulterating lard. The oil is sometimes filtered with a small percentage of fuller's earth, to improve its color and brightness.

(C) Mutton tallow.

A fine article of mutton tallow is also sometimes used in lard, but the objection to the flavor is sufficient to limit its use to a small amount.

(D) Beef fat.

The following general remarks on beef fat will be found instructive:

Before the day of the oleomargarine industry all fat rendered from the tissues of cattle was known commercially as tallow. Since then differentiation has taken place and the term tallow is no longer sufficient to designate the several products obtained from the rendered fat of the beef. We have first "butter stock," which is rendered from the caul fat at a low temperature and from which is manufactured by means of pressure—

(1) Oleo-oil.

(2) Oleo-stearin (beef stearin).

The kidney fat as a rule is left with the carcass and constitutes what is known as suet. Marrow stock, as its name implies, is rendered marrow fat, and when properly prepared is almost equal to butter stock in quality. Tallow is made from the trimmings and portions of the viscera. Its color varies from white to yellow according to the portions of the animal which have been used and the care with which they have been prepared for rendering and the temperature at which rendered. When freshly and carefully rendered, tallow should show less than 1.5 per cent of free fatty acid. The tallow on the market will show anywhere from 2 to 10 per cent. Its flavor varies, never being good enough for lard. Tallow grease corre-

sponds to the yellow grease of the hog-packer. It is of a dark color and often contains as much as 50 per cent of free acid. It is made into low-grade soaps.

(E) COTTON OIL.

(*a*) The cotton seed from various sources is put through a screen to take out the bolls and coarse material. The seed is then put through a gin to remove as far as possible any remaining lint, of which about 20 pounds per ton of seed are obtained.

The clean seed is next sent to a huller composed of revolving cylinders covered with knives, which cut up both seed and hull. The chips are then conveyed to a screen placed on a vibrating frame, through which the kernels fall. The hulls are carried by an endless belt to the furnaces, where they are burned. The kernels of the seed are conveyed to crusher rolls, where they are ground to a fine meal. The meal is then sent to a heater, where it remains from twenty to forty minutes. These heaters have a temperature of 210° to 215° F. The hot meal is formed into cakes by machinery; these are wrapped in cloth and placed in the press. About 16 pounds of meal are put in each cake. The cakes are placed in a hydraulic press where a pressure of from 3,000 to 4,000 pounds per square inch is applied. The press is also kept warm. The expressed cakes contain only about 10 per cent of oil. The cake is sold as cattle food or for fertilizing purposes. The crude oil as thus expressed contains about 1.5 per cent of free acid. The chief cotton-seed-presses of the country are located at the following points:

Cotton-seed oil milling points.

Arkansas:	Illinois:	North Carolina:
Little Rock.	Cairo.	Charlotte.
Argenta.	Louisiana:	Raleigh.
Fort Smith.	New Orleans.	Tennessee:
Texarkana.	Shreveport.	Memphis.
Brinkley.	Baton Rouge.	Jackson.
Helena.	Monroe.	Nashville.
Alabama:	Missouri:	Dyersburg.
Selma.	Saint Louis.	Texas:
Mobile.	Mississippi:	Brenham.
Montgomery.	Clarksdale.	Dallas.
Eufaula.	Columbus.	Galveston.
Huntsville.	Canton.	Houston.
Georgia:	Grenada.	Palestine.
Atlanta.	Greenville.	Waco.
Augusta.	Meridian.	
Albany.	Natchez.	
Columbus.	Vicksburg.	
Macon.	West Point.	
Rome.		

The oil is chiefly pressed in winter, since it is difficult to keep the seed for summer work. Some mills are, however, operated during the summer. The crude oil is shipped in tanks holding from 36.000 to 45,000 pounds each. When the oil is shipped north in winter it usually becomes solidified. In order to get it out of the tanks they are placed on switches and a jet of steam is introduced into the tank and the oil gradually melted out. Another method consists in covering the tank with wood, forming a chamber into which exhausted steam is introduced. Gutters are provided along the railroad tracks into which the oil flows and is conducted into the receiving tanks. From the receiving tanks it is pumped into large receivers called scale tanks, where the crude oil is weighed.

(*b*) *Refining process.*—After weighing, the oil is pumped into refining kettles. These are of various sizes, the largest ones being 20 to 25 feet deep and 15 feet in diameter. These tanks are furnished with steam coils for tbe purpose of heating

the oil and with appropriate machinery for keeping it in motion. A solution of caustic soda is used for refining. This solution is made from 10° to 28° Beaumé in strength, and varying quantities are used according to the nature of the oil operated upon. After the addition of the caustic soda the mixture is agitated for forty-five minutes and kept at a temperature of 100° to 110° F. The contents of the tank are then allowed to stand six to thirty-six hours, when the solid matters, soap and substances precipitated by the caustic alkali, gather at the bottom. This mixture is called "foots," and is used for making soap. The yellow oil resulting by this process is further purified by being heated and allowed to settle again or by filtration, and is called summer yellow oil. Winter yellow oil is made from the above material by chilling it until it partially crystallizes and separating the stearine formed, about 25 per cent, in presses similar to those used for lard. This cotton-oil stearine is used for making butterine and soap.

(c) *White oil.*—The yellow oil obtained as above is treated with from 2 to 3 per cent of fuller's earth in a tank furnished with apparatus for keeping the mixture in motion. When the fuller's earth has been thus thoroughly mixed with the oil, the whole is sent to the filter press. The fuller's earth has the property of absorbing or holding back the yellow coloring matter, so that the oil which issues from the press is almost white. This white oil is the one which is chiefly used for making compound lard.

Cotton oil is obtained from the seeds of *Gossypium herbaceum.* The percentage of oil varies in the seed from 10 to 30.

In 1882 it was estimated that the oil industry was represented by the following data :*

410,000 tons of seed, yielding 35 gallons of crude oil to the ton, are 14,350,000 gallons, worth 30 cents per gallon	$4,305,000
Same amount of seed, yielding 22 pounds cotton lint to the ton, is 9,020,000 pounds cotton, worth 8 cents per pound	721,600
And yielding also 750 pounds of oil-cake to the ton (2,240 pounds) is 137,277 tons of cake, at $20 per ton	2,745,540
	7,772,140
Deduct the sum paid for the seed, say	4,100,000
And there remains for value gained in manipulation of seed	3,672,140

From September 1, 1883, to September 1, 1886, there were exported from New York, 88,871 barrels, and from New Orleans, 186,720 barrels, making a total of 275,591 barrels from the two ports. These figures show conclusively that American cotton-seed oil is growing rapidly in favor in foreign countries.

When well stored and properly ventilated, cotton seed keeps sweet for twelve months. If allowed to become damp, or stored too long in bulk, it grows heated and is liable to spontaneous combustion.

Manufacture of cotton-seed oil.—The seed when landed at the mill is first examined. If too damp or wet it is dried by spreading it over the floor with free access of air, exposing it on frames to the sunlight in warm weather, or by kiln drying. Drying is the exception rather than the rule in the United States. Cotton ginning is so carefully done that the seeds have little or no opportunity to become wet. Besides this, the seed is generally held at the gins for some time before it is sold to the oil manufacturer.

The first process in preparing the dry seed for the mill is to free it from dust. This is effected by shaking it in a screen or in drums lined with a fine metallic net and containing a strong magnet to which any iron nails will adhere, which are fre-

*Brant. Vegetable and Animal Oils. Phil. H. C. Baird & Co.

quently present. From the drums the seeds drop into a gutter leading to a machine which removes the lint left by the gin. This is done by a gin constructed for the purpose, with saws closer together than the ordinary cotton gin. An average of twenty-two pounds of short lint is taken from a ton of the seed. This product, called "linters," is used in the manufacture of cotton batting. The clean seeds are then transferred to the sheller, which consists of a revolving cylinder containing twenty-four cylindrical knives and four back knives. The sheller revolves at great speed, and as the seed is forced between the knives the pericarp or hull is broken and forced from the kernel. The mixed shells and kernels are separated in a winnowing machine by a strong blast of air. This removal of the husk makes a vast difference in the meal cake, a desiccated or decorticated cake being five times more nutritious and wholesome than an undecorticated cake.

Being thus cleaned, shelled, and separated, the kernels are carried by a system of elevators to the upper story and then pass down into the crusher rolls to be ground to flour.

Cold pressure produces a very good salad oil, and this is the method generally pursued in Marseilles and other European cities for the first pressure, after which the residue is subjected to a second warm pressure. In this country, however, warm pressure is generally preferred. The meal is heated in a meal heater for fifteen to twenty minutes to 204.4° to 215.3° F.

The heated meal is placed in woolen bags, each holding sufficient seed for a cake, The bags are then placed between horse-hair mats backed with leather having a fluted surface inside to facilitate the escape of the oil under the hydraulic pressure amounting to 169 tons. With the most improved presses the hair mats are, however, done away with. The bags remain in the press seventeen minutes, the solid "oil cake" of commerce remaining behind. This cake forms a superior feed for cattle, horses, sheep, and especially swine, and is nutritious, easily digested, and fattening.

Cotton-seed cake is of a rich golden color, quite dry, and has a sweet, nutty, oleaginous taste. When ground to the fineness of corn meal it is known as "cotton-seed meal," and in that form is frequently used for fertilizing purposes.

The crude oil as obtained from the press is pumped into the oil room and either barreled for shipment or refined.

Four qualities of the oil are known:

Crude oil is thickly fluid and of a dirty yellow to reddish color; on standing it deposits a slimy sediment. The *second* quality has a pale orange color and is obtained by refining the crude oil. The *third* quality is obtained by further purification of the second; and the *fourth*, which has a pale straw color and a pure nutty taste, by bleaching the third quality.

The coloring principle, termed *gossypin*, is collected on a filter, carefully washed to remove any trace of acid, and dried slowly at a low temperature. It is then ready for use as a dye, and gives fast colors on both silk and wool. It is claimed that the quantity of coloring matter in a ton of crude oil is 15 pounds, though this proportion must vary considerably. Its properties are insolubility in acids, slight solubility in water, free solubility in alcohol or alkalies. In its dry state it is a light powder of a pungent odor, of a brown color, and strongly tinctorial.

Crude cotton seed is thickly fluid, twenty-eight to thirty times less fluid than water, and has a specific gravity of 0.9283 at 68° F., 0.9306 at 59° F., and 0.9343 at 50° F.

According to the quality of the oil, palmitin is separated between 54° and 43° F. The oil congeals at 28.5° to 27° F. In taste and odor it resembles linseed oil, and as regards other properties it is an intermediate between drying and nondrying oils.

Refined cotton-seed oil has a specific gravity of 0.9264 at 59° F.; it separates palmitin already below 53.5° F., and congeals at 32° to 30° F.

The oil consists of palmitin and olein, and to make it still more adapted for the adulteration of olive oil, for which immense quantities are used every year, it is intentionally cooled for the separation of palmitin, which lowers the specific gravity.

MIXING.

The term refined lard has long been used to designate a lard composed chiefly of cotton oil and stearin. The largest manufacturers of this kind of lard have now abandoned this term and are using the label "lard compound" instead. This is but just to the consumers of this article who are likely to be misled by the term refined lard. The prime steam lard in a state of fusion, the stearin also in a liquid condition, and the refined cotton oil are measured in the proportions to be used and placed in a tank at a temperature of 120° to 160° F. In this tank the ingredients are thoroughly mixed by means of paddles operated by machinery. After mixing the compound lard passes at once to artificial coolers where it is chilled as soon as possible. It is thence run directly into small tin can or large packages and prepared for market.*

VEGETABLE OILS.

In the East, cocoanut oil is largely used in cooking and in medicine while fresh, and for burning, painting, soap-making, and anointing the body when rancid.

There are many kinds of comestible oils obtained from various plants and used by the natives of all countries. I will not attempt to enumerate here the varieties exhibited in the French Colonial section. Some of them are of much local importance, but do not enter into foreign commerce. Bambouk butter is one such oil, obtained by the natives of West Africa from the large seeds of the butter tree, *Butyrospernum Parkii.*

Castanha oil is extracted from the castanha or Brazil nut. It is used for cooking purposes when perfectly fresh.

Chequito is a name applied by the Kaffirs of southeast Africa to a fatty substance yielded by the fruit of the "butter tree." It is largely used by them in admixture with their food, and is exported. It consists of about 25 per cent oleine and 75 per cent margarine, and possesses an aromatic flavor.

Cocoa butter, or oil of theobroma, is a valuable concrete, fatty oil, derived from the seeds or beans of the cocoa tree. It is obtained during the process of chocolate making. The beans are ground in heated mills by which the oil is disengaged and becomes a soft paste which is put in canvass bags and the oil pressed out. Its principal use is in pharmacy.

Oil of ben, made from ben nuts, the seeds of one or more species of *moringa,* is used in the West Indies as a salad oil.

Boma-nut oil is much used in cooking by the natives of Central Africa.

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*U. S. Department of Agriculture, Division of Chemistry; Bulletin 13, part 4, Food and Food Adulterations, pp. 403-554.

In Morocco, *Argan oil*, made from the seed kernels of the argan tree, is used as a substitute for olive oil.

Bean oil, made from the Chinese oil bean, is still used in China as food, though its principal use is for illuminating.

Sunflower oil, obtained from the seeds of the sunflower (*Helianthus annus*) when purified, is by some considered quite equal to olive oil and almond oil for table use.

Walnut oil, in the fresh state, is used in Switzerland and some other countries as a substitute for olive oil for salads, etc.

Melon oil, made from the seeds of the sweet melon, is largely used as food, as well as for illuminating purposes and for soap. In China and in Africa there is an extensive commerce in the seeds, which are exported to Europe.

Almond oil, made from the Java almond, is largely used by the inhabitants of the Moluccas for cooking, when fresh, and for burning in lamps.

Ground nut, or peanut oil, is largely sold for olive oil. In Java, the oil is extracted by drying the nuts in the sun and then subjecting them to pressure. In European mills the nuts are first cleaned, then decorticated and winnowed. The cleaned kernels are then crushed and put into bags and subjected to cold pressure for the first yield of oil. The cake remaining is then ground and pressed under 3 tons to the inch, in the presence of steam heat, yielding a lower grade of oil. Sometimes there is a third pressure, but the product of the first only is for food purposes.

Gingelly, or Sesame oil, of superfine quality, is largely used in Europe as a substitute for olive oil. It is made from the seeds of *Sesamum indicum*, common to many tropical and subtropical countries. The Turkish dominions, India, Siam, China, Corea and Japan, produce large quantities of the seeds and oil. It is also grown in the southern parts of the United States and through Central America to South America. In East Africa the oil is extracted by pounding the dry seeds in a mortar, adding a little hot water until the oil begins to appear, and then squeezing the mass with huge pestles, after which the floating oil is ladled off. France is largely engaged in making oil from imported seeds, the Levant seeds being considered the best. There are three processes of expressing the oil. The first yield, by simple pressure, affords the superfine oil. The cake is then softened with cold water and again pressed, affording a second grade of oil, and the cake is then treated with steam and hot water for a third pressing, affording another grade of oil.

Gamboge-butter is made from the seeds of *Garcinia pictoria*, growing in India. It is used by the better natives as a lamp oil, and by the poorer as a substitute for ghee.

Cotton-seed oil is becoming a commercial food product, being used for cooking purposes, and also very largely as a substitute for olive

oil, being sold as olive oil, or as an adulteration. In packing sardines in Maine, refined cotton-seed oil is largely employed in place of olive oil, and there seems to be no reason other than popular prejudice why its use should not be general.

Cotton-seed oil prepared in beef fat has become a commercial article in the United States as a substitute for hog lard for household use. The importance of the cotton-oil industry in America is discussed in pages 599–602.

OLIVE OIL AND ITS PREPARATION.

The most important commercial oil for food purposes is that obtained from the olive, *Oleo europa.* There are as many as thirty varieties of the species of olive distinguished by different botanists as the result of long cultivation. The great seat of the olive-oil industry is in the countries bordering the Mediterranean, whence the olive tree has been introduced into America, Australia, and some other lands. In California, olive culture has in recent years become of great importance.

The annual yield of olive oil in the world is estimated at 50,000,000 kilograms, made chiefly in Italy, France, Spain, and Dalmatia. The importations into France in 1887 were—

	Kilograms.
Spain	1,234,931
Italy	16,583,339
Algeria	3,289,889
Other countries	1,509,483
Total	22,617,642
Valued at	28,045,875 francs.

The exportation of this oil from France in 1887 was 6,219,091 kilograms.

Olives vary in shape, sometimes round, sometimes obovate, but they are generally of oval form. They grow in great profusion. To obtain the best oil, they should be harvested just on the eve of maturity; if too ripe, more oil but of inferior quality is the result. Spanish olives are the largest, those of Andalusia being the best in Spain.

In extracting oil from olives there are two processes, crushing and pressing. The crushing is usually done with stones. The crushed pulp is then shoveled into bags and submitted to slow pressure. The product of the first pressure yields the best quality, or "Virgin oil." A small amount of oil drains from the crushed olives before the pulp is pressed. This is of great purity, and is used chiefly by watchmakers. The marc or cake taken from the bags after the first pressing is thoroughly mixed with boiling water, and is submitted to pressure more powerful than the first. The second oil is nearly as good as the first, but is apt to become rancid. Most of the oil is

skimmed off the water in the receivers, and after a thorough separation has taken place the operation is reversed by drawing off the water from below. The cake is again mixed with hot water and subjected to a third pressing, which yields a third quality of oil. The water used in the several operations still contains some oil. It is allowed to stand until the mucilage settles to the bottom and the oil rises to the surface, when the oil is skimmed off. The only purification practiced in southern Europe is to allow the oil to stand for a long time and deposit its sediment.

Spanish and Portuguese oils are not as good as Italian and French. The exhibits of olive oil were very numerous, France, Spain, Portugal, South and North America, as well as Australia and Japan, were fully represented.

The olive oil industry is increasing in importance each year, as the culture is extended into new regions. In Europe the olive tree flourishes between 35° and 45° north latitude. It will grow in a temperature as low as 38°, but will not withstand heavy frosts.

In Italy, the olive is abundant in all the southern provinces, of moderate height, but does not flourish in mountainous regions. Soil containing much limestone, dry or rocky, and inclined toward the south seems best suited to its culture. The methods of its cultivation vary much in different countries.

In general, trees not very tall, and having the form of a vase are less likely to injury from intense heat or violent winds.

Harvests are abundant only one year in four or five. The fruit is generally gathered when it begins to fall. In France the harvesting lasts from the end of November to the end of January. In Italy the season commences toward the end of autumn and lasts several months.

The degree of maturity of the olives affects the quality of the oil. If not ripe enough, the oil is puckery and of small amount. If too ripe, the oil is thick and of unpleasant taste. In some localities the olives are allowed to fall themselves before they are gathered.

MANUFACTURE OF OLIVE OIL AT NICE.

The method of preparing olive oil is thus described by United States Consul Hathaway:

The gathering of the crop begins in November and continues until May. The harvests are divided into three periods of two months each. From the first is produced an oil high colored and called "fine;" the second produces a straw-colored oil called "superfine;" the last a pale colored oil called "extra superfine." The product of the first period is most dense and has a stronger flavor of the fruit, and can be longest preserved.

But the best quality of the oil is that from the last gatherings of April and May, when the fruit has become fully ripened. This, although less flavored than the others mentioned, has more sweetness and limpidity, and is in great demand in the home markets, and not always easily procured for export in its finest grades.

To express the oil from ripe fruit freshly gathered and unmixed with that which is immature or otherwise of bad condition is an essential rule, and to this method the reputation of the oil of Nice is mainly due. The olives are gathered from small trees by hand and from large ones they are knocked off by poles. The first manner is preferable, as the fruit thus escapes being bruised, and as any lengthy contact with the soil affects its flavor. But this can not so readily be practiced either on large trees or slopes or fields of large extent. Women and boys are employed for this purpose, for which as wages they receive 77 cents for every 20 liters.

The mills for grinding the olives are located on the little water courses of the region, and a stone wheeling round on its axle triturates the fruit and reduces it to paste. The latter is then placed in bags of esparto and squeezed under a press in the mill. The olive oil then escapes through the texture of the bag and runs into a receptacle underneath. It is this first pressure which produces that which is styled "virgin oil." Afterwards the bags of said paste are removed and soaked in boiling water and placed a second time under the press. The same operation is a third time repeated, when all the remaining oil is extracted. The second pressing yields the ordinary oil of commerce and the third that used for illuminating purposes, and generally consumed here in preference to all other oils. It is styled "huile de colza."

The farmers bring their oil to market in barrels of about 200 pounds weight, or retain it in their cellars in earthen jars, glazed within, and guarded from dust by wooden covers. Merchants keep it in large, deep, cemented tanks, over which their warehouses are built, thus providing an even temperature.

From the tanks the oil is drawn by pumps for the process of filtration and bottling for sale. The filter consists of a series of boxes, one above the other, with perforated bottoms, and lined with layers, about an inch in thickness, of white cotton wool.

That the adulteration of the olive oil, notwithstanding the severe penalties of the law therefor, is to some extent practiced is undoubted. The fraud is accomplished by mixing with the genuine the oil of the oleaginous seeds of cotton, sesamum, and others. Immediate discovery of the imposition appears impossible, although much study has been given to the matter.

Densities, degrees of congelation, refraction, specific weight, and all other chemical properties must be taken into consideration, which is a labor of hours. The following process of detection is generally used:

In the trial tube is placed 0.3086 grains of dried albumen, to which is added 30.864 grains of nitric acid and an equal weight of oil. The tube is then heated over an alcohol lamp and its contents mixed by ebullition.

The operation affords the following tests: (1) If the oil be genuine olive the color will be of a yellow, feebly greenish, tint; (2) if the olive has been mixed with 5 per cent of seed oil the color will be of an amber-yellow tint; (3) the tint of the mixture will deepen down to a deep orange in proportion to the amount of the foreign oil.

VII.—REVIEW OF EXHIBITS BY COUNTRIES.

AMERICA.

UNITED STATES.

The United States exhibit numbered only seventeen entries, but included samples of most of the products naturally embraced in this class, such as lard, condensed milk, butter and cheese, cotton-seed oil,

olive oil, and some other fats, besides an interesting exhibit by Dr. Thomas Taylor of microphotographs showing the structure of animal and vegetable fats.

The farm value of the production of milk, butter and cheese in the United States in 1887 is estimated by the Department of Agriculture at $385,000,000, as follows: Milk, $158,000,000; butter, $194,000,000; cheese, $33,000,000.

In 1880, there were 12,443,120 milch cows in the United States. There was made in that year 806,672,071 pounds of butter and 243,157,850 pounds of cheese. About 3 per cent of the butter, and nearly 30 per cent of the cheese was made in factories, the balance on the farms.

The Committee on Agriculture of the House of Representatives reported in 1886 as follows: In the United States there are over 15,000,000 cows, producing annually over 1,000,000,000 pounds of butter and 300,000,000 pounds of cheese, worth $250,000,000. An amount of milk of equal value is annually consumed, making the total value of dairy products $500,000,000.

Exports of milk, butter, and cheese from the United States, 1879–1880.

Year.	Butter.		Cheese.		Condensed milk, value.
	Pounds.	Value.	Pounds.	Value.	
1879	38,248,016	$5,421,205	141,654,474	$12,579,968	$119,883
1880	39,236,658	6,690,687	127,553,907	12,171,720	121,013
1881	31,560,500	6,256,024	147,995,614	16,380,248	139,470
1882	14,794,305	2,864,570	127,989,782	14,058,975	200,490
1883	12,348,641	2,290,665	90,220,467	11,134,526	180,505
1884	20,627,374	3,750,771	112,869,575	11,663,713	203,008
1885	21,683,148	3,643,646	111,992,990	10,444,409	221,284
1886	18,953,990	2,958,457	91,877,235	7,662,145	255,864
1887	12,531,171	1,983,698	81,255,994	7,594,633	258,971
1888	10,455,651	1,884,698	88,008,458	8,736,304	294,806

The foreign trade in imitation butter and oleo oil has been discussed on a preceding page under the heading of those products.

Most of the imitation butter exported went to the West Indies. Two-thirds of the oleo oil went to Holland, and about one-sixth to Germany. The butter was sent to nearly all countries, the greatest purchasers being England and the West Indies. England and Scotland bought seven-eighths of the cheese exported and Canada one-tenth, while the balance was very widely distributed. China and Japan bought half the milk exported ; England one-fourth, and the United States of Colombia one-fifth.

The importation of dairy products into the United States in 1888 was as follows:

Products.	Quantity.	Value.
	Pounds.	
Butter	143,215	$26,429
Cheese	8,750,185	1,214,936
Condensed milk	....	376,062
Total	8,893,400	2,089,281

The butter came chiefly from the Dominion of Canada. Of the cheese, 5,597,674 pounds came from Switzerland, 1,172,005 pounds from Italy, 864,090 pounds from Holland, 425,965 pounds from France, and 396,703 pounds from Germany.

The annual production of lard in the United States is about 600,000,000 pounds, one-half of which is pure lard and the other half compound or "refined" lard, made from pure lard mixed with stearin and cotton oil.

The exports of lard in 1887 were 321,533,746 pounds, two-fifths of which was compound lard.

The methods of making lard in this country are discussed on a preceding page.

THE WEST INDIES, CENTRAL AND SOUTH AMERICA.

The Dominican Republic showed some oil and grains of sesame, and some cocoa oil.

Mexico exhibited some oils and fats.

Salvador had an exhibit of cheese.

Nicaragua had an exhibit of butter in boxes.

The United States of Colombia was awarded a silver medal for some oils exhibited in this class.

Chile had two exhibits of lard.

Uruguay exhibited cheese and some ostrich eggs.

There were five exhibits of lard, butter, pistache and oils from Brazil. The butter and lard, however, were not of very fine quality. Although Brazil is a great cattle country, the dairy industry is of little importance. Butter and cheese are imported from Europe, while the undeveloped resources of the country in this industry are capable of supplying all home demands and producing a large surplus for export.

The lard industry of Brazil is of considerable importance. Some good samples of lard were shown in the Brazilian court, but the quality was not equal to American production. The same may be said of butter, which is made in several factories, but the quality is inferior to that of American and French production, which is an article of importation.

Cheese is made in several provinces, especially in the province of Mindo Guraes.

Much progress has been made in the dairy industry in the Argentine Republic during the past five years. Some salted butter and some cheese of fair quality were shown at the Exposition.

The condition of this industry in 1883 is told as follows by Mr. E. L. Baker, United States consul at Buenos Ayres:

It may seem paradoxical, yet it is true that while the Argentine Republic contains about 12,000,000 of horned cattle, it produces neither milk, butter, nor cheese, while the beef itself is, generally speaking, so inferior—at least in this part of the country—as to be the subject of universal execration. Such a thing as a dairy farm is unknown; such a thing as butter-making, in the true sense of the word, is a myth; such a thing as a cheese factory, if we except a cheap curd produced at Goya, has never been attempted. In this immediate neighborhood you may or you may not find milk enough for your coffee, but not elsewhere. Nobody, with rare exceptions, keeps a milch cow. Butter, if it is used at all, has until very recently been brought from Italy. Of late years an unsalted butter, the work of Spanish Basques settled near Buenos Ayres, has been finding its way to market, but it is nothing more than coagulated cream, whilst the cheese comes from England and Germany.

Not long ago I visited an estancia stocked with 15,000 cattle, and we did not have a mouthful of butter for our bread, while our coffee was seasoned with condensed milk from Illinois. Cattle have never been raised in the Argentine Republic either for the milk, butter, or cheese they produce, but especially for slaughter.

The small number of milch cows in the province of Buenos Ayres, compared with the total number of cattle, will attract attention, while in the other provinces—could figures be obtained—the discrepancy would be still greater; whereas in the United States over one-third of all the horned cattle of the country are cows kept for dairy purposes.

I will not assume to say that Yankee churns are unknown in this country, but a good portion of the butter which finds its way to the city is churned by the *lecheros* on horseback on their journeys to town by the mere jolting of some cream in the tin cans strapped across the horse's back.

But the most novel mode of making butter in the interior is to fill a bag made of hide with some cream, then fasten the bag to one end of a long hide rope and attach the other to the leathern girth around a horse's body, which is then mounted by a gaucho and ridden at a breakneck pace over the pampa for a sufficient length of time to secure the making of the butter by bumping the milk bag against the ground.*

The exhibits from the Argentine Republic included olive oil and other oil, butter, cheese, beef, and hog and ostrich fats.

EUROPE.

AUSTRIA-HUNGARY.

Austria-Hungary showed three exhibits of oil of juniper, juniper powder, and some albumen and other products of eggs. The Hungarians consume much milk and sweet cream and only use butter made from sweet milk. Cheese is made in much the same manner

* United States Consular Reports: Cattle and dairy farming, pp. 603, 617.

as in Holland and Switzerland. In the north of Hungary, they make a cheese of sheep's milk used by the peasants. It is in the form of a dry powder and and has a sweet taste. It is known as *Lipto* cheese and is packed in small barrels of conical shape.

BELGIUM.

Belgium had two exhibits of fresh and salt butter and comestible oils. The butter industry has long been of great importance in Belgium. Besides the large home consumption, there is some exportation. Artificial butter is extensively used and manufactured, and is also imported from Holland. In 1882 the total importation of butter was 19,000,000 pounds, chiefly to Holland and France.

DENMARK.

Denmark is so extensively engaged in the dairy industry that we might expect a large display of Danish butter, cheese, etc. There was but one exhibition of varieties of cheese made from cow's milk and goat's milk.

Butter, cheese, and eggs are among the principal exports from Denmark.

The annual exports of butter from Denmark from 1877 to 1882 averaged 19,000,000 pounds. The use of centrifugal machines becoming general, the exports increased to 26,000,000 pounds from 1883 to 1885. In 1886 they were 32,000,000 pounds, in 1887 about 40,000,000 pounds. The exportation of butter in 1887 was 880,000 pounds.

Very great progress has been made in Denmark in recent years in the manufacture of butter, and it is to that country that we owe the introduction of some of the most useful improvements in dairy machinery. The salt butters made in Denmark are of fine consistency, excellent flavor, and will keep well. The reputation of Danish butter is due not so much to the good quality of the milk as to the methods of manufacture. Two processes of creaming are employed, the Swartz and the centrifugal machines. The former system depends on separation by refrigeration, the latter method is mechanical. The operation of washing butter with water is very seldom employed in Denmark, the separation of the buttermilk being accomplished by a centrifugal machine which leaves the butter with all its aroma and fineness.

The butter-making machines are also of the most improved design. A description of dairy apparatus belongs to class 49.

FRANCE.

In France there are about 6,000,000 cows, and the production of milk during the year 1887 was 74,887,555 hectoliters (1,647,526,210 gallons), valued at 1,195,523,269 francs.

In 1882 the number of cows kept was 5,019,670 and the yield of milk was 68,205,965 hectoliters. Of this amount, 36 per cent, or 25,035,328 hectoliters, was made into butter and cheese, and 64 per cent, or 33,170,637 hectoliters, was consumed as milk.

The details of the butter and cheese made in 1882 are as follows:

	Quantity of milk employed.	Total production.	
		Butter.	Cheese.
Rich cheeses:	*Hectoliters.**	*Kilograms.*†	*Kilograms.*
From milk partly creamed	2,149,921	2,271,628	14,773,423
From milk not creamed	3,552,384	....	43,403,524
Poor and thin cheeses:			
From skimmed milk	19,333,023	70,773,680	54,362,722
	25,035,328	73,045,308	112,539,729

* 22 gallons. † 2.2 pounds.

The values of the above in francs are as follows:

	Value.		Average price per kilogram.	
	Butter.	Cheese.	Butter.	Cheese.
Rich cheeses:				
Milk partly creamed	5,090,389	17,914,540	2.24	1.21
Milk not creamed	....	57,773,680	....	1.33
Poor cheeses	158,981,287	42,140,141	2.24	0.77
	164,071,676	117,858,364		

The value of the goat's milk annually produced in France is estimated at $20,000,000.

Imports of dairy products into France in 1886 *and* 1887 (*imported for consumption.*)

	1886.		1887.	
	Quantity.	Value.	Quantity.	Value.
	Kilograms.	*Francs.*	*Kilograms.*	*Francs.*
Condensed milk (with sugar)	204,797	286,716	196,910	275,674
Condensed milk (pure)	7,725	19,815	6,415	8,981
Milk (natural)	1,971,843	394,369	2,045,274	409,055
Cheese (white, soft)	1,447,157	2,098,386	1,317,777	1,910,777
Cheese (other kinds):				
Netherlands	4,842,519	....	4,380,332	....
Italy	693,586	21,961,092	750,001	20,697,372
Switzerland	9,506,382	....	8,790,694	....
Other countries	643,982	....	862,810	....
	15,686,469	....	....	....
Butter (fresh)	6,376,930	....	6,185,617	....
Butter (salt)	371,236	....	374,990	....

Exports of French dairy products in 1887.

	Quantity.	Value.
	Kilograms.	*Francs.*
Condensed milk (with sugar)	10,444	14,622
Condensed milk (pure)	16,870	24,461
Cheese (white, soft)	1,341,817	2,012,725
Cheese (other kinds)		
Italy	509,194	4,480,806
Switzerland	117,423	
Algeria	1,211,928	
Other countries	1,251,680	
Butter (fresh)		
England	1,796,594	16,410,717
Belgium	2,822,245	
Switzerland	344,953	
Algeria	272,817	
Other countries	233,030	
Butter (salt)		
England	20,375,124	66,460,200
Brazil	2,500,500	
Other countries	1,295,358	
Margarine	8,151,460	10,597,909

Butter and milk in France.—Great improvement has been made in the manufacture of butter by the introduction of centrifugal machines for separating the cream. The creaming is done cold or warm. Experience has shown that the temperature has a direct influence on the yield and the quality of the cream, and though the yield per hour is less at a low than at a high temperature, preference is given to the cold creaming.

Many styles of churns were shown at the Exposition, but they were not superior to those of American invention. There were a number of mechanical "butter workers" exhibited. Among these I may mention those made by Hignette, which were in operation daily and did the work well.

The salting of butter is now generally done with brine instead of dry salting. France takes a high rank for excellence of butter, though it is not altogether tasteful to the American tourist so accustomed to highly salted butter. Isigny butter is known far and wide as the best of French butter and equal to any made in Europe, if not in the world.

The manufacture of condensed milk is of very little importance in France, the supplies for the navy and colonial use being imported from Switzerland and other countries.

All the improved methods of keeping fresh milk by refrigeration and other methods are practiced in France.

Pure cream, slightly salted, thickened, and molded in various forms is sold in Paris under the names *gervais*, *petits suisses*, etc.

A fine dessert cream cheese is made by wrapping the cream in

linen cloth. The most common mold for this cheese is in the shape of a heart. Fresh cream is poured over it when served.

The price of cheese made from milk partly creamed varies from 70 centimes to 2 francs 40 centimes per kilogram. Dry cheese is worth from 25 centimes to 1 franc 40 centimes per kilogram.

Butter varies in price from 1 franc 10 centimes to 3 francs per kilogram.

The varieties of French cheese are discussed on a previous page under the general heading "Cheese."

THE UNITED KINGDOM.

Great Britain had only one exhibit, but that was a very complete one by the "London and Provincial Dairy Company." A dairy fully equipped with half a dozen cows and all the improved appapatus for the care of milk and cream and the manufacture of butter was in full operation during the entire Exposition. As dairy machinery belongs to another part of the report, it is not for me to describe it.

The United Kingdom is a very large purchaser of dairy products. In 1888 the imports were as follows:

	Quantity.	Value.
Butter ....cwt..	1,669,314	£8,902,193
Margarine............. ....do...	1,138,174	3,263,826
Cheese..........................do...	1,917,541	4,542,278
Eggs ....qr. hun..	9,320,617	3,077,109

The exports of domestic dairy products in 1888 were as follows:

	Quantity.	Value.
Butter..........................cwt..	25,618	£145,730
Cheese..........................do...	12,799	50,743

The exports of foreign dairy products were:

	Quantity.	Value.
Butter... ....cwt..	64,393	£326,758
Margarine............ ....do....	20,457	50,614
Cheese. . ...do....	58,869	172,105

It is unfortunate that there were no exhibits of the well-known cheddar, Stilton and other cheeses of England, and of the excellent butters made in Ireland.

GREECE.

Greece had twenty-eight exhibits of comestible oils, and one exhibit of various kinds of cheese.

ITALY.

Italy had sixteen exhibits of olive oil, butter, some Gorgonzola cheese, and other products.

NETHERLANDS.

The Netherlands had sixteen exhibits of butter and cheese.

The dairy industry of Holland was represented by some fine specimens of butter and cheese, and a fully equipped dairy in operation, selling milk and cream to Exposition visitors.

Butter and cheese are among the principal productions of Holland not only for home consumption but also for exportation. In 1887 the exports of butter aggregated 77,974,500 kilograms, valued at 62,379,598 florins, four-fifths of which went to England. Of cheese, the exports were 30,534,805 kilograms, valued at 10,687,179 florins. About one-half the cheese was sent to England, one-tenth to France, and one-twentieth to Hamburg.

Holland is a large importer of oleo oil for the manufacture of artificial butter. In 1888 the imports from the United States aggregated 25,950,000 kilograms. Cotton-seed oil is also imported into Holland by the butter-makers, the amount in 1888 being 55,000 barrels, or about 9,000,000 kilograms bought from the United States, England, and from Turkey or Egypt.

SWEDEN.

There were no exhibits of dairy products catalogued from Sweden, although a dairy called "Swedish Dairy" was in active operation in the Esplanade des Invalides during the several months of the Exposition.

NORWAY.

Norway had only one exhibit in this class, some sterilized milk made by the Dahl process.

PORTUGAL.

Portugal had a very complete series of samples of olive oil, shown by about four hundred and fifty exhibitors.

ROUMANIA.

Roumania had an exhibit of Assan Frères, of Bucharest, showing cotton-seed oil and other vegetable oils extracted by benzine. There was also an exhibit of cheese.

RUSSIA.

There were four exhibits of cheese, butter, sunflower oil, and other oils from Russia. The Grand Duchy of Finland had seven exhibits of fresh and salt butter, and some goat's-milk cheese. The butter shown was perfectly made and of good color. The export trade averages about 100,000,000 pounds each year.

SAN MARINO.

San Marino, the oldest existing and the smallest republic in the world, had three exhibits of cheese and oils.

SPAIN.

Spain had thirty exhibits of olive and other oils, and three exhibits of butter and cheese. The dairy industry of this country is of comparatively little importance. The butter shown was salted for export trade. The cheeses were in considerable variety of forms and quality.

SWITZERLAND.

The annual production of milk in Switzerland is 330,000,000 gallons, of which 319,000,000 gallons are cows' milk. The value of the product is from $40,000,000 to $42,500,000. It is estimated that 147,400,000 gallons are made into butter and cheese, and 6,600,000 gallons prepared as condensed milk.

The annual exportation of butter, cheese, and condensed milk is about $10,000,000. Switzerland made an excellent display of dairy products including all the varieties of cheese for which she is famous, also butter, condensed milk, and some farines lactees. The latter product is made from cows' milk condensed *in vacuo* at a low temperature, to which are added finely powdered wheat bread and a little sugar.

AFRICA.

Algeria had one hundred and fifty-three exhibits of olive and other oils, and two exhibits of goat cheese and fats.

Senegal took a diploma of honorable mention for some oil.

Tunis had several exhibits of oil.

ASIA.

Japan showed some olive oil, the result of experimental culture.

French India had one exhibit of butter and one of oil.

AUSTRALASIA.

There was only one exhibit from Australia in Class 69, some olive oil produced on the experimental farm in Victoria. The production of milk, butter, and cheese in Victoria in 1887 was valued at $14,000,000.

New Zealand exhibited some butter in kegs and in tins. Dairy farming is of some importance in New Zealand There are several cheese factories equipped with machinery imported from the United States.

New South Wales imported in 1886 27,940 cwt. of butter, valued at $797,680, against 32,366 cwt. at $590,975 in 1885. Almost all of the imports come from New Zealand and other Australian countries.

The cheese imported, also coming almost entirely from adjacent colonies, amounted in 1886 to 1,229,334 pounds, worth $217,540.

The exports of butter to the neighboring colonies in 1886 were 58,047 pounds. Some shipments were made to Great Britain in the refrigerating chambers of the Orient line of steamers.

The cheese exported was 11,386 pounds, at $2,085, in 1886.

The copöerative system of making butter has much extended to New South Wales during the last few years. There are now twenty-six factories in operation.

The milk is taken to the factory as soon as obtained from the cow, and the pails brought back to the dairy thoroughly cleansed by steam. The butter is sent to market in tubs or jars holding about 100 pounds each. As soon as it reaches market, it is either sold out of the tubs or pressed into rolls by the butter dealer.

Experiments are now being made in salting butter by immersing it in strong brine in the granular state, and pressing it into rolls with machinery.

VIII.—REPORT BY MR. JAMES CHEESMAN.

We are indebted to Mr. James Cheesman, of Massachusetts, a member of the jury of awards on Class 69, for the following interesting report:

The exhibits of eatable fats and oils, fresh milk, preserved milk, salt and fresh butter, cheese, and eggs of all kinds included in this class have been very large, though by no means complete.

Over 850 entries of oils, lards, butter, cheese, and condensed milk have been on exhibition, and more than nine-tenths of these are oils. Portugal heads the list with 448 exhibits of very high quality; Algeria follows with 155; France, 66; Spain, 33; and Greece, 29. In the United States exhibit we have but 20 entries of oils, lard, butter, cheese, and oleomargarine.

The oils exhibited by the largest producers, France, Italy, Spain, and Portugal, are excellent, and forecast great possibilities for the still further development of our cotton-seed oil trade. The absence of technical processes of manufacturing these oils at the Exposition renders it impossible to treat the subject of oils to anything more than a mere passing allusion.

The preserved-milk trade is small, though continually on the increase; there is nothing of special value worthy of notice in this article beyond the general statement that our own exhibits are of very high quality and compare well with the other makers of the world.

On the fresh milk much may be said, if enough of accurate data were available for the purpose. The only opportunity I have had of studying French milk has

been found in occasional visits to the "vacheries," the creameries, and other places where milk is sold. Considering many of the Paris cow-stable proprietors profess to provide milk for the special use of infants and invalids, it would be a very desirable thing to have their cows regularly inspected and reported on once a month. In the early part of May I visited several of these places and found quite a serious proportion of the herds had severe coughs and most probably something still worse.

It would be infinitely better to have all cows removed from the cities to the country, where they could be better cared for and be more cheaply kept than is possible at present. The plan of penning cows in closed stalls for 8 or 10 months is certainly not the healthiest, and the cost and kind of fodder supplied are neither cheap nor as healthful as when fed on the farm. As a rule, the milk supplied from these places is rich and well flavored, analyzing over 13 per cent of dry matter, of which about one-third is butter fat. Although the milk can be delivered twice daily immediately after milking, complaints are by no means uncommon that the milk does not keep. Antiseptics are very generally used to secure the milk after it is delivered to the customer.

In the United States much more milk is used per capita than in France, and the age of the milk varies from one to two days old, according to distance of the farm from the city. The airing and cooling to low temperatures practiced by Americans permit milk to be held much longer than would be possible in France.

The price of milk in Paris varies from about 7 cents per quart to 14. The cheap milk varies in quality and condition very much; the higher priced milk is delivered in bottles through specially appointed agents of the farms which produce it. Boracic acid and other antiseptics are much more freely used in France than with us, as our main reliance is on ice. Antiseptics would be used still less in the United States if the dealers could be reasonably sure that their milk would be properly cared for by servants after delivery at the customer's domicile.

Machines like Hill's aerator are entirely unknown here, and yet the employment of this machine by the farmer makes all the difference between sweet and sour milk in hundreds of thousands of places where it is used.

The Hill machine is very much like a bellows. A long tube is placed in the milk, and a current of air is passed through it until the milk is perfectly odorless; an operation requiring about 3 minutes. Milk thus purified, and afterwards cooled to a temperature of 45° will keep without any antiseptics whatever, from 5 to 10 days. This method of treating milk is of great importance to the steamship trade, and no less to the children and other persons to whom milk is as great a necessity as meat. With us milk is very much more of a beverage than it is in France.

The control of the milk supply by the municipal laboratory of Paris gives the consumer a reasonable guarantee of quality. Municipal law requires a milk of 13 per cent of total solids. Although the milk is sampled quite regularly for analysis, there is no inspection of the cows and no regular examination of the milk for pathalogical Bacteria. Systematic work of this kind in large cities like Paris and London might be undertaken by the governments with a view of elucidating some of the sanitary problems involved in the milk supply of large cities.

Butter, such as is ordinarily met with on Paris tables, is in marked contrast to the goods found under similar circumstances in the United States. With us, artificial color is used very extensively in winter, and in a few places the year round, to gratify a taste for dark-colored goods. The extensive introduction of Channel Island cattle, and the widespread use of pure-bred butter bulls in the United States, coupled with the rich grass of our pastures, produce milk of very rich quality.

The stimulation of the majority of our farmers in the older settled portions of the States having a considerable live-stock interest, to acquire greater knowledge of dairying, favor the manufacture of very superior butter all over the country.

The standing of our butter may be best indicated by a reference to any of the

principal butter markets in the great cities. In New York, Boston, Philadelphia, and Chicago, butter may be met with in every conceivable form and package—pale orange, deep gold, very fresh, well salted, high flavored, delicately flavored, firm, well grained, neatly packed, or printed very tastefully, but all cool, if not in refrigerators.

With us, all butter worth 40 or more cents per pound is produced on large farms, where the same tools and implements are available as in factories, or it is made in creameries, where the product of from 600 to 2,000 cows is worked up daily. The cream is separated either by some of the approved gravity methods or it is run through the centrifugal machine.

The cream obtained is carefully set aside at a low temperature till enough is obtained for a churning, then the whole is heated to 60° or 63° F. for 12 hours, less or more, according to the condition of the cream and the judgment of the operator.

At the time of churning, the bulk of the cream is of equal age all through ; the churning is accomplished in from thirty-five to forty-five minutes, at standard temperature, and the butter obtained is well granulated and of equal merit all through.

The after treatment of the butter is most carefully conducted throughout. After repeated washings, at a temperature of 52 to 56°, in this granular state in the churn, the butter becomes firm and hard, in which condition it is removed from the churn to the worker, where it is carefully spread out with a rake to permit the salt to be more evenly distributed with a fine sieve than would be possible otherwise. The salt is raked in and the butter is worked just enough to incorporate the salt and to express needless water. After working, it is placed in the packages in which it is delivered to the consumers, 5, 10, or 20 pounds, or printed and packed in the butter-carrying boxes, and marked next day.

In France there is no lack of useful machines and other tools necessary for the production of fine butter. The tools of various makers, many of them identical with our own, are here, but they are not in use to any extent. In the dairy districts from which France draws her supplies the herds are, for the most part, small, and the appliances crude. The churnings are on the farms where but few cows are kept, and each churning will represent cream of different ages. The churn is the old Normandy barrel, which some American dairymen were familiar with 10 or more years ago.

For the benefit of the younger men not familiar with this tool, I will simply add that it is a barrel suspended horizontally from the heads on trunnions. Inside are the old fixed dashers, and the churnings take, according to the condition of the cream, from thirty minutes to two hours.

The resulting products of a thousand or more churns are brought together at frequent intervals during the week for sale to merchants, or manufacturers, as they are called. Three times these butters are lumped together, as in the Chicago imitation creamery packing houses, taken to a central packing house, sorted according to quality, washed, salted, ground, and packed ready for the Paris and London markets.

There are some fancy grades of butter, but these goods are, like our own, made on the farm and marketed by the maker.

The one lesson French dairying has for us is the early marketing of goods. If we would make no more butter in summer than we really need for trade demands, there would be no surplus to get stale, and no old goods to be marketed in winter when the winter cows come in.

The greatest reform needed in American dairying is to produce every month in the year just enough for the demand and no more.

Cheese-making in France is essentially different from anything that we have in the United States. In France cheese is seldom or never eaten as the primary con-

stituent of a meal, and is therefore consumed in much smaller quantities than our own makes of cheese. A really good French cheese is little short of a work of art. They vary in shape, size, flavor, and color very much. Some of the better known makes are already well known to American consumers under their familiar names of Camembert, Brie, and Roquefort. The number of cheeses made in France is great, but only a few varieties need be noticed to insure appreciation of the great difference of character. Although a good trade has already been established in a few of these cheeses, perhaps the Camembert is by far the best known, as it deserves to be. The best test of merit is to use it on a delicate stomach, which almost invariably responds to the high digestibility of this cheese. Like the cheese of other lands, the French name their cheeses after the towns of their country. Hence, the Livarot, Pont l'Eveque, and many other similarly named.

The mode of treating the milk for the production of these cheeses is not materially different from the Cheddar process, but the mode of treating the curd is altogether different. After the curd has been hooped and allowed to drain for a day, it is removed to a drying room, where the curing process is partly begun; from here it is taken to the caves proper, where the curing process is carried on to the end. These caves are fitted with a sash, a wire screen, and a wooden shutter, so that if it is desired to admit light and exclude air, the sash is used; if both light and air, the wire screen only, but if it is necessary to exclude both light and air, then the shutter is used. The floor of the cave is of bare earth, and the moisture used in this chamber comes entirely from the moisture in the ground. In the course of time, these cheeses change color and flavor until the stage is reached which commends itself to the judgment of the producer.

The appearance of the cheese at different ages is the sole guide to the progress of their curing. The salting is done by rubbing in from the first a small quantity of salt.

American cheese excited a good deal of attention among the Jury. The Young America, the Cheddar, the sage, and the pine-apple cheese were greatly relished and admired by every member who tested them. The cheeses were deliciously mellow, and were completely digested in every sense of the term.

The lard exhibits of the United States showed up remarkably well—firm, well cooked and smooth-bodied goods. There is nothing of moment to report in this article, our methods of lard production being entirely different from anything practiced on the continent. In Europe, steam rendering is partially used, but much of the lard made is still rendered by fire furnaces. The American products have been closely examined; the purity, firmness, and color of our lards have provoked many comments.

Considering France is preëminently a poultry country, it is somewhat strange that eggs are not cheaper and fresher. It is surprising that more rapid and expeditious methods of collecting eggs from the peasantry are not adopted, and that they do not transport the collections more frequently from places of delivery.

CLASS 71.—PRESERVED MEAT AND FISH.

CLASS 71.—PRESERVED MEAT AND FISH.

I.—GENERAL REVIEW OF THE INDUSTRY.

The exhibits included in Class 70 under the general classification, are (1) salt meats, meats preserved by various processes, meat and soup cakes, hams and prepared meats; (2) poultry and game; (3) salt fish, packed fish, codfish, herrings, etc., fish preserved in oil; sardines, pickled tunny fish, etc.; (4) lobsters, shrimps, oysters, etc.

Nearly all nations participating in the Exposition displayed food products preserved by the methods peculiar to each country. There was, however, little to notice in new processes of preservation. Dried, salted, and canned meats, fish, and secondary products were shown in bewildering variety.

In the French section the display was naturally superior to all others in attractiveness of packages and often also in the quality of the products.

The general classification made no provision for the exhibit of fresh or frozen meats or fish, although they were shown in some sections to illustrate methods of refrigeration. The Argentine Republic sent over some frozen mutton and beef and kept it in good condition for some months in a large refrigerator.

The aggregate weight of beef annually consumed for food in the world is enormous indeed. The total number of cattle in Europe and America is estimated by the French department of agriculture at 175,000,000, distributed in 1882 as follows:

Country.	Number of head.	Number per 100 inhabitants.	Country.	Number of head.	Number per 100 inhabitants.
United States	*41,171,762	82.5	Switzerland	1,035,930	37.5
Canada	3,514,989	81.2	Spain	2,353,000	15.8
Argentine Republic	14,206,499	488.0	Portugal	698,000	14,8
Uruguay	7,300,000	1,665.7	Denmark	1,470,078	74.7
Australia	8,644,540	297.8	Sweden	2,257,048	49.0
Algeria	1,070.324	32.2	Norway	1,016,617	56.2
France	12,996.984	34.5	Russia (except Poland)	23,845,104	31.1
Great Britain	9,882,417	28.0	Roumania	1,858,000	34.6
Belgium	1,382,815	24.5	Servia	964,000	51.7
Holland	1,427,936	33.8	Bosnia	762,000	64.4
Germany	15,786,764	34.5	Greece (except Thessaly)	279,000	14.1
Austria	8,584,077	38.8	Total	171,888,650	
Hungary	4,597,543	29.2			
Italy	4,783,232	16.6			

*In 1887 there were 50,331,042 cattle in the United States.

From the above table we see that the great producing countries are the United States, Argentine Republic, Russia, Germany, and France. The meat exports from the Argentine Republic in 1887 were:

	Kilograms.	Value.
Meat and packed beef	23,984,243	$2,398,243
Concentrated meat	12,038,889	963,112
Extract of meat	37,944	75,888
Meat powder	61,000	15,250

The countries of Europe in which tne importation of cattle exceeds the exportation are Great Britain, Belgium, France, Switzerland, and Portugal. The demand of these countries is partly met by other European countries, but there is still a deficit of 100,000 head that are drawn from America, chiefly from the United States and Canada.

England is the greatest importer, and is followed by Belgium and France. In 1876 England imported 8,613,400 kilograms of fresh beef, 12,054,200 kilograms of salt beef, and 14,452,300 kilograms of beef preserved by various processes. In 1888 the imports were 837,444 cwt. fresh, 226,536 salted, and 542,599 cwt. preserved. In 1889, the imports of fresh beef had increased to 1,379,511 cwt.

The annual production of butchers' meat in Russia is estimated at 1,963,388,700 kilograms and the consumption at 1,798,524,000 kilograms, thus leaving a considerable amount for exportation.

Europe, exclusive of Switzerland, demands annually about 3,175,000,000 kilograms of meat, the consumption per capita in each country being nearly as follows:

	Pounds.		Pounds.
Great Britain and Ireland	129	Austria-Hungary	68
France	93	Spain and Portugal	54
Denmark	88	Greece	44
Germany, Belgium, and Netherlands	85	Italy	27
Sweden and Norway	76	Russia	43

The latest general statistics of the number of hogs in Europe and America aggregate 100,000,000, nearly half of which are in the United States. Among the countries that may be enumerated as having more than a million hogs are the following:

United States	*46,000,000	Italy	1,164,000
France	7,146,996	Spain	2,349,000
United Kingdom	3,956,495	Portugal	1,052,000
Germany	9,206,195	Russia (except Poland)	10,574,000
Austria	2,721,541	Servia	1,679,000
Hungary	4,803,639	Canada	1,207,619

*In 1888 the number was 50,301,592.

In Europe the hog-exporting countries are Russia, Servia, Denmark, Roumania, Austria-Hungary, Italy, Holland and Belgium. France is coming to be an exporter rather than importer. In 1884, the excess of exports over imports were 3,358 heads.

Germany is the principal importer of pork—the imports exceeding the exports by more than 1,000,000 head. Portugal imports about 60,000 head more than are exported, and Switzerland about 40,000. Great Britain imports about 25,000 more hogs than are exported, but in that country there is a large importation of hams, bacon and lard. In 1889 Great Britain imported 3,498,144 cwt. of bacon, 269,587 cwt. of salt pork, 116,846 cwt. of fresh pork, and 977,608 cwt. of hams. More than three-fourths of these imports were sent from the United States, Germany and Holland supplying a large share of the balance.

The European consumption of frozen beef and mutton from Australia and America is an industry of recent origin. In 1880, there were only 400 carcasses of mutton and lamb brought to London and Liverpool from South America, while in 1888 there were 873,460 carcasses from that country and more than a million carcasses from other regions. I quote some valuable statements from a trade review, of the frozen meat traffic at London and Liverpool.

Number of carcasses of mutton and lamb imported into England from 1880 *to* 1888.

	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	Total.
Into London:										
Australia..	400	17,275	57,256	63,733	111,745	95,051	66,960	88,811	112,214	613,445
New Zealand....	......	....	8,839	120,893	412,349	492,269	655,888	766,417	939,231	3,395,886
River Plate.	......	....	....	17,165	108,823	190,571	331,245	242,903	197,460	1,088,167
Falkland Island ...	......	....	....	....	....	....	30,000	45,552	....	75,552
	400	17,275	66,095	201,791	632,917	777,891	1,084,093	1,143,683	1,248,905	5,173,050
Into Liverpool:										
River Plate.	.....	....	....	....	....	....	103,454	398,963	676,000	1,178,417
Total	400	17,275	66,095	201,791	632,917	777,891	1,187,547	1,542,646	1,924,905	6,351,467

Condition on arrival.—The great bulk of these carcasses came to hand in good condition. Of 445 shipments received into London, only 31 have been more or less seriously damaged. The proportion which these unsound cargoes bear to the total import has steadily decreased from 10 per cent in 1883 (when the trade began to assume important dimensions) to 4 per cent in 1888. In consequence, to some extent, of this improvement, it has already been found practicable to reduce the premiums charged for insurance against "all risks" from £6 6*s*. per cent to £4 per cent.

Quality.—On the whole, the quality of New Zealand shipments has tended to deteriorate, while the quality of River Plate sheep has tended to improve year by year. The average weight of the former has steadily fallen away from about 70 pounds (in 1883) to about 56 pounds, while the average weight of the latter has as

steadily increased from about 40 pounds to about 45 pounds. It is earnestly to be hoped that New Zealand shippers will in no way relax their efforts to maintain the superior quality of their mutton, which has hitherto, with good reason, easily maintained the foremost position. This is rapidly becoming a matter of increasing importance to them in view of the growing strength of the competition with the Argentine Republic—not only in point of the number of carcasses received thence, but now, also, in respect of their improving quality.

Charges.—These have been gradually reduced from say 4*d.* per pound in 1883 to about 2½*d.* per pound, the total cost now involved in freezing and consigning for sale to this market, so that the present price of 3¾*d.* per pound is nearly as remunerative to shippers as when in 1883 to 1885 as much as 5½*d.* to 6*d.* per pound was obtainable. Refrigerating charges, freight, insurance, storage, cartage, railway carriage, and consignees' commissions have all been reduced. The only charge which has not yet suffered any diminution is salesmen's brokerage, which has remained at 2 per cent. Unsuccessful endeavors have repeatedly been made to secure a reduction in that item, but the manner of distribution of supplies has weakened the hands of consignees in dealing with this and other matters affecting the handling of the meat.

Lambs.—As a rule more of these have reached England than could advantageously be disposed of. The quality of New Zealand imports has not been satisfactory, the bulk of the carcasses being too small. The outlet for frozen lambs is not only actually but proportionately more restricted than that for frozen mutton, and must always remain so. Lamb being so much of a delicacy must be of good quality or i t can not be sold to advantage. The poorer districts, which absorb a very large proportion of frozen mutton, offer no important outlets for lamb. The season here does not coincide with the time of year at which the bulk of New Zealand lamb shipments arrive. In effect, frozen lambs are largely offered for sale in this market before there is any general demand for it. The best months for its disposal here are April, May, June, and July.

Beef.—Supplies of colonial beef have arrived too intermittently to secure the establishment of a regular trade. New Zealand shippers have tried to "catch the market" in England, but generally with indifferent success. Relative values are completely dominated by those current for American beef, and the course of that market is very uncertain. When American beef is cheap, frozen beef is practically unsaleable. So long as colonial beef must be frozen hard and can not be thawed without sustaining injury to the tissues it will not command that attention here which its original good qualities would otherwise warrant.

Vessels engaged in the trade.—Referring to the table of importations, the number of vessels engaged in the trade is now fifty-seven, of which the actual carrying capacity and annual carrying capacity are as follows:

	Number of vessels.	Actual carrying capacity.	Quantity wh ch could be carried per annum.
		Carcasses.	*Carcasses.*
New Zealand to London	*10 †16	101,000 459,000	1,220,000
Australia to London	†10	48,000	145,000
River Plate to London and Liverpool	†21	347,000	1,040,000
Total	57	955,000	2,405,000

* Sailers. †Steamers.

The total imports can thus be considerably augmented even with the present fleet. The carrying capacity of some of the colonial steamers is capable of being appre-

ciably increased, and additions to the River Plate section of the above list are in course of being made.

Storage accommodation.—The space now available for the storage of frozen meat in London and Livepool is equal to the accommodation of about 350,000 to 420,000 carcasses, according to size of carcasses and method of storing. In London there are eight land stores and two floating hulks, capable of holding some 250,000 to 300,000 carcasses, while additional refrigerators are now in course of erection. In Liverpool there are three stores, with a capacity of 100,000 to 120,000 carcasses. Throughout the provinces several small stores have been erected, notably in Birmingham, Manchester, and Glasgow.

The following statistics, taken from the recently published Agricultural Returns for 1888, indicate the importance of the trade in imported meats, viz:

Total number of cattle and sheep in the United Kingdom at 4th June in each year.

	1883.	1884.	1885.	1886.	1887.	1888.
Cattle	10,097,943	10,422,762	10,868,760	10,872,811	10,639,960	10,268,600
Sheep...........	28,347,560	29,376,787	30,086,200	28,955,240	29,401,750	28,938,716

Total imports of beef and mutton into the United Kingdom.

	1883.	1884.	1885.	1886.	1887.
Live cattle ....No..	474,750	425 507	373,078	319,622	295,961
Live sheep ....do...	1,116,115	945,042	750,886	1,038,965	971,404
Beef (fresh).......................cwts..	804,794	878,350	902,951	806,867	656,194
Mutton (fresh).......... ....do...	236,496	503,194	572,868	653,447	783,114
Total	1,041,290	1,381,544	1,475,819	1,460,314	1,439,308

For the purpose of comparison we have converted the live stock imports into cwts. of dead meat, with the following result, viz :

	1883.	1884.	1885.	1886.	1887.
Beef imported..........................	3, 70,000	3,537,000	3,233,000	2.803,000	2,505.000
Mutton imported	734,000	925.000	908.000	1,117.000	1,216,000
Total imported	4,504,000	4,462,000	4,141,000	3,920,000	3,721,000
Of which frozen mutton:					
From New Zealand.................	72,000	240,000	283,000	346,000	399,000
From other sources	38,000	111.000	142,000	240,000	325.000
Total	110,000	351,000	425,000	586,000	724,000
Percentage of frozen mutton to total imports of mutton.......	15	38	47	52	60
Percentage of New Zealand frozen mutton to total imports of beef and mutton	1½	5	7	9	11

The population of this country is steadily increasing at the rate of about 1 per cent per annum, while the aggregate live stock has during the past three years decreased at the rate of about 3 per cent per annum. It is apparent, therefore, that in order to maintain the existing rate of consumption without depleting home

flocks and herds, a material extension of the import trade must take place, and colonial shippers should be prepared to take their share in the further development of that trade. As to the capabilities of the leading centers of frozen meat production, it is only needful to quote the following approximate figures—the latest available in each case; viz:

	Population.	Cattle.	Sheep.
Great Britain and Ireland	38,000,000	10,268,600	28,938,716
Australia	3,000,000	7,860,971	79,111,615
New Zealand	600,000	853,358	16,564,595
Argentine Republic	4,000,000	19,000,000	90,000,000

The 170,000,000 sheep in Australia and the Argentine Republic may not be to any important extent suitable or available for export to this country, but the efforts of late years made by many owners—especially in the Argentine Republic—to modify the character of their flocks in view of the requirements of the markets in this country, must ere long tend largely to extend the area whence can be drawn the now necessary supplies of frozen mutton.

New Zealand shippers must always bear in mind the fact that the River Plate is yearly increasing its output of frozen mutton, that trade being assisted by a lower charge for freight, etc., a bounty on exports, and the advantages of a rate of exchange which enables sales to be advantageously made in this country at apparently low prices. Steps are being taken there for further extension of the trade, and the results of efforts made in recent years for the improvement of the quality of shipments have not yet been fully felt. As yet the quality of New Zealand mutton is very distinctly superior to either Australian or River Plate produce, and if care be taken to preserve the advantage thus held there is every reason to anticipate a constantly growing demand for it on that account alone.

Review of the market for 1888.—When the year opened great uncertainty prevailed as to the probable course of values for home-fed mutton, the drought for the previous year having been seriously, but to an unknown extent, detrimental to the flocks and herds throughout the country. The agricultural returns, recently published, show that a serious loss in numbers resulted from that cause, aggravated by the severity of the winter of 1887-'88 and the inclemency of the succeeding spring and summer. The actual decrease in the returns for 1888, as compared with those for 1887, proved to be 4.8 per cent in the case of cattle and 2.7 per cent in the case of sheep. The effect of this diminution was only gradually made apparent in the course of relative values, which, with varying strength, advanced steadily from the beginning of January till the end of July. Thereafter quotations receded slightly, as is almost invariably the case during the autumn and early winter months, but nevertheless a clear gain of 1*d.* per pound was established in the value of Scotch and English mutton in the London market between January and December. Home-fed beef, however, remained steady throughout the year. The general purchasing power of the community appears to have slackened somewhat, as it has barely sufficed to maintain values with a marked reduction in the total available supply.

As regards frozen mutton, the outlook at the commencement of the year was not encouraging. The stock held in London was about 140,000 carcasses, the same as in January, 1887, and there was the prospect (subsequently fully realized) of increased importations. The course taken by the market, however, was altogether different from what could then have been expected. Early in the year it became manifest that the demand for all kinds of frozen mutton, largely fostered by the low range of values current in the latter part of the previous year, had apparently increased throughout the country. Stocks steadily decreased notwithstanding the

fact that during the first three months of the year 225,000 sheep were received from New Zealand and Australia, as against 161,000 during the first quarter of 1887. The severity of the weather and the shortness of the supply of low quality English mutton brought to market greatly assisted the hardening tendency of quotations, and the prices of colonial mutton at the end of March were one-fourth to three-eighths pence per pound better than in January. The first half of the year witnessed a reduction of stocks in London from 140,000 carcasses to 90,000 carcasses, although in the interval 556,000 sheep had arrived in London from Australasia, as against 436,000 sheep during the corresponding period of 1887. Prices during April, May, and June remained steady at a level about one-fourth pence per pound higher than that at which the year opened. In the third quarter of the year the import of New Zealand mutton fell from 218,000 carcasses in 1887 to 177,000 carcasses in 1888, and stocks remained within very moderate compass, as compared with the experience of some recent years. Supplies were at that period less freely distributed over the market than as a rule is the case, so that during July holders were enabled to secure a prompt advance in values. Prices touched 5½*d.* per pound for New Zealand mutton and 5*d.* per pound for Australian in August. During September the position was nominally maintained at about one-eighth pence per pound under these figures, but the general demand had slackened off as usual at that time of year and the trade was only quiet. In October supplies of English and Dutch sheep and American beef became very plentiful, and, as arrivals of frozen mutton from New Zealand increased in volume, stocks again accumulated and quotations rapidly declined. Between the middle of October and the middle of December values fell from 5¼*d.* to 4*d.* per pound. The year closes with trade in a most depressed state and the stock of frozen mutton undesirably heavy. The import of Australasian mutton into London for the last quarter of 1888 amounted to 283,308 carcasses as against 186,913 carcasses in 1887. The position of the market during November and December must have proved discouraging to many New Zealand shippers who hoped that the advance established in the summer months was likely to be maintained. The price of meat throughout the country, as an almost invariable rule, falls off towards the end of the year because supplies are then most plentiful, and the year 1888 has formed no exception to that rule.

UNITED STATES OF AMERICA.

The display of meat products by the United States was arranged by the Department of Agriculture. As the exhibits and the methods of the meat industry in our country are fully discussed in another volume, I shall not enter into details in the present chapter.

All the principal meat products of the United States were represented at the Exposition. Armour & Co., the Fairbault Canning Company, Curtice Bros. & Co., E. T. Cowdrey & Co., Richardson & Robbins, George Brouglun, The Franco-American Soup Company, J. H. W. Huckins & Co., Michener & Co., Swift & Co., G. Cassard & Son, and some other of our leading firms displayed samples of salted, smoked and canned meats, fish and soups, in great variety of attractive styles and in excellent condition.

In 1886 the production of meat in the United States was valued at $784,000,000 and the exports of meats at $62,522,185. This was the farm value exclusive of increased value on account of transportation charges, etc.

The exports were the greatest in 1881, when the value aggregated $100,000,000, while in 1888 it was $60,000,000, a decrease due chiefly to prohibitory legislation by European nations. The quantities and kinds of meats exported in 1888 were as follows :

Value of exports of beef from the United States, 1855-1887.

	1855.	1865.	1875.	1887.
Live cattle	$24,860	$159,254	$1, 03,085	$9,172,136
Fresh beef				7,228,412
Salt beef	2,600,547	3,308,730	4,197,956	1,972,246
Canned beef				3,462,982

Exports of meats from the United States, year ended June 30, 1888.

	Pounds.		*Pounds.*
Beef, canned	40,458,375	Pork, fresh	63,187
Beef, fresh	93,498,273	Pork, pickled	297,740,007
Beef, pickled	48,980,269	Pork, bacon	331,306,703
Beef, other cured	104,151	Pork, hams	44,132,980
Mutton	224,738		

The number of live cattle exported in 1888 was 140,208, valued at $11,577,578.

Exports of fresh beef from the United States during the years 1877 *to* 1888.

	Pounds.		*Pounds.*
1877	49,210,990	1883	81,064,373
1878	54,046,771	1884	120,784,064
1879	54,025,832	1885	115,780,830
1880	84,717,194	1886	99,423,362
1881	106,004,812	1887	83,560,874
1882	69,586,466	1888	93,498,273

Pork packing is one of the leading industries of our country. The number of hogs in the United States in 1888 was 50,301,592, or more than half the total number in the world, and in that year the exports of pork products included 63,187 pounds fresh pork, 297,740,007 pounds salt pork, 331,306,703 pounds bacon, and 44,132,980 pounds of hams.

The States of Illinois, Iowa, Kansas, Missouri, Wisconsin, Nebraska, Ohio, and Indiana, known as the States of "corn surplus," raise immense numbers of hogs. Corn grows there in such abundance that it is more profitable to raise hogs and to send corn to market as pork than to transport the corn direct. A pamphlet of twenty-one pages descriptive of the pork packing and other meat industries of the United States was published by the Department of Agriculture and distributed at the Exposition. This interesting pamphlet is reprinted in another volume of these reports.

FRANCE.

The total consumption of meat in France in 1882 was officially reported as 1,251,449,841 kilograms, of which 1,162,020,181 kilograms

were of domestic production, and 89,429,660 kilograms were imported in the form of living animals or as cut meats. Beef constituted 55 per cent of the total amount, mutton and goat 14 per cent, and pork 31 per cent. The total value of the meat is given at 1,984,152,911 francs, or nearly $400,000,000.

The proportion of different kinds of meat included in the above is shown by the following table:

Quantity of meat consumed in France in 1882 (*Animals slaughtered in France*).

	Kilograms.	Francs per kilogram.
Beef	524,240,725	1.57
Veal	160,765,082	1.64
Mutton	149,137,292	1.79
Goat	2,338,895	1.02
Lamb and kid	16,172,586	1.49
Pork	386,966,147	1.51
Suckling pigs	338,625	1.33
Total	1,239,959,352	

Cut meat imported.

	Kilograms.
Fresh beef and mutton	6,045,615
Salted meats	3,714,897
Preserved meats	5,194,676
	14,955,188
Less exports	3,464,699
Consumed	11,490,489
Total meat consumed	1,251,449,841

Goat meat to the amount of 2,338,895 kilograms was eaten in France in 1882. This does not include a large quantity of kid which is classed with lamb and is considered a luxury. Goat is not generally sold as such, but as mutton, though in some portions of France this meat is salted and smoked.

The consumption of meats in fresh condition is everywhere increasing in France, chiefly because of the great development of cheap and rapid means of transportation to distant points. This increase is apparent in cities as well as in the country.

Meat is more tender and of better flavor a day or two after the animal has been killed. Among the Abyssinians beef is eaten raw while yet warm and bloody, the animal not being killed until just before the meal.

The butcher shops of Paris are models of cleanliness. Dealers in fresh meats do not sell salted provisions and there are separate shops

for dealers in pork products. Horse, mule, and donkey meat is not sold by the beef butchers, but in distinct shops, with appropriate signs, and the meats are plainly labeled "horse," "mule," and "donkey," and the price of each per pound.

Concerning the French trade in frozen meat from South America, I quote from the report by Frank H. Mason, United States consul at Marseilles (dated December 2, 1887):

In a recent report from this consulate the fact was stated that during October of last year two new monthly lines of steamers had been established between the port of Marseilles and Buenos Ayres. These, added to the three regular lines already existing, gave during the month of November seven departures of steamers for the Argentine Republic. How well this increased service is justified by the commerce of France with the rapidly growing valley La Plata is attested by the fact that to-day no less than three large steamships are clearing from this port for Montevideo and Buenos Ayres. The smallest of these carries 1,150 emigrants (mostly Italians), and all have full cargoes of freight largely made up of manufactured goods of French origin.

But it is not merely through her export trade that France has secured important and valuable relations with the Argentine Republic. During the past six months a reciprocal enterprise has been established for the importation of dressed meats from that country, and fresh beef, mutton, veal, and game are now brought from Barracas in regular cargoes and sold to the butchers of Havre, Rouen, Paris, and other principal cities of France.

In view of the extraordinary capacity of the United States for meat production and our already important traffic in dressed meats with Great Britain, it may be of interest to define precisely the local conditions under which this new enterprise has been established, and which would apply equally to similar imports from the United States.

The Company "Saminena" which has slaughter houses and a refrigerating establishment at Barracas, near Buenos Ayres, constructed last year two steamers, the *Belgrano* and *San Martin*, especially adapted for that service. These steamers, which are rigged with movable compartments or chambers to receive the meat, ply regularly between Barracas and Havre. When the meat is discharged at the latter port the partitions which form the compartments can be taken down and stowed, thus making room for ordinary freight outward bound, and overcoming the hitherto fatal financial difficulty involved when refrigerator steamers have been obliged to make the return voyage in ballast.

The process of preparing the meats for shipment includes nothing new or mysterious. Whole carcasses of mutton and veal and half carcasses of beef are hung in dry-air chambers chilled to 25° or 30° centigrade below the freezing point until the inmost parts of each piece are frozen solid and the germs of putrefaction, if any exist, are completely chilled. Once frozen to this solid condition in the packing house, it is only necessary to keep the meat during transportation in a temperature sufficiently cold to prevent thawing. For this purpose 8° or 10° centigrade below zero is found to be quite sufficient. The compartments on shipboard are made of double walls of wooden planking, with a layer of pulverized charcoal between, and are kept cold by a refrigerating machine operated by an engine of 50 horse power attached to the boilers of the steamer. At Havre, Paris, and Rouen, where depots have been established, tight chambers are provided similar in construction to those employed on board, except that the former are larger and of course not arranged for dismounting. At all these depots, as well as on shipboard and at the principal slaughterhouse in Barracas, refrigeration is produced by compressed-air machines

of the Hall pattern, which are manufactured at Dartford, England. In the depot at Paris a gas motor of 15 horse power drives a machine of sufficient capacity to keep four large chambers at the required temperature. For transporting the frozen meat from Havre to Rouen and Paris box cars, with double wooden walls, have been found adequate, even in warm weather.

Thus equipped the company began operations during the past summer, its first cargo of meat reaching Paris on the 7th of July in perfect condition. As a test of the system of preservation, a carcass of lamb was hung for three days before a meat stall in Paris during the warmest weather in July, and upon being subsequently cooked was found perfectly sweet.

So far from impairing the firmness of the meat fiber and its power to resist putrefaction, the intense freezing process, as is now claimed, enhances both these qualities.

The meats imported by this company are sold to retail dealers in all French cities where depots have been established, at the following prices:

Meats.	Per kilogram.	Per pound.
	Francs.	*Cents.*
Mutton	1.20	10½
Lamb	1 40	12½
Beef:		
Hind quarter	1.40	12¼
Fore quarter	1.00	8¾
Veal	1.20	10½
Saddle of mutton	1.40	12¼
Sheeps' tongues	*2.50	*48¼

* Per dozen.

At these prices there is realized by the company a net all-round profit of 9 centimes per kilogram, equal to $15.75 per ton of 2,000 pounds, or between 7 and 8 per cent of the average value of the merchandise.

These prices are sufficiently below the cost of native meats to attract purchasers, and as the French have few petty prejudices against foreign food products, the frozen meats from La Plata met a ready and extensive sale, one stall at the Halles Centrales at Paris retailing, as early as the 5th of August, an average of 200 carcasses of mutton per day. The whole undertaking has been, in fact, practically successful at every step, and the development which it may reach in France will only be limited by the capital and enterprise of the company.

Let us now examine the general conditions by which this and all similar undertakings are estimated in this country. All dressed meats imported to France from any country not allied by special commercial treaty pay an import duty of 12 francs per 100 kilograms, equal to $21 per ton of 2,000 pounds.

Austria, Italy, and Germany have special commercial treaties with France, which enable dressed meats from those countries to be entered at the French frontier on payment of 3 francs per 100 kilograms, or one-quarter the general rate which, in default of such treaty, would apply to meats from the United States and Argentine Republics, but meats in all these countries are costly and their surplus production is more or less limited.

Besides this there is the octroi or local municipal duty of 11.80 francs per 100 kilograms imposed by Paris and most other French cities upon all meats entered for consumption within their limits. In Marseilles this octroi duty has long been established at 25 francs per 100 kilograms or 2¼ cents per pound for the purpose of favoring the extensive abattoirs maintained by the city, which might otherwise meet seri-

ous competition from meats imported from abroad or brought in a dressed condition from the surrounding country.

This excessive octroi duty, more than double that of any other large city in France, would more than consume the profits of importation, and until reduced puts Marseilles out of the list of municipalities which can profit by the use of meats imported from America.

An effort has been made to secure the reduction of present octroi rates to uniformity with those of other large cities, but thus far without success.

The problem which has been solved by the Company Saminena has been that of slaughtering and freezing beef, veal, lamb, and mutton on the Plate River, importing the same by their own steamers via Havre, though an import duty of $21 per ton and a city octroi of $20 per ton is imposed, and selling those meats in perfect condition at prices which, although less than the values of native meats, yields a net average profit of $15.76 per ton.

Do the conditions as herein stated offer an opportunity for the meat-growers and exporters of the United States?

Pork is one of the principal meats eaten in France. The consumption in 1882 was 387,304,772 kilograms of pork, which was 30 per cent, of the total meat consumption. Careful attention is given to the fattening of the hogs and to the preparation of the meat in attractive form for table use. The animals raised in France are of the following principal races: (1) a black hog, common in the south; (2) a piebald race in the center and west, and (3) two white races in the north. The pig of the valley of the Auge in Normandy is fed on clover and luzerne and fattens easily, growing to a weight of 600 pounds. The white pig of Poitou grows to 450 pounds. The crossing of the breed with the black pig of Perigord produces the much esteemed piebald breed of the West.

During the progress of the Exposition there was a competitive exhibition of hogs from all parts of France. The animals were of course selected ones and they were certainly interesting to the populace.

It does not pertain to this report to discuss the hog industry in general, but only to consider the methods of preparation and preservation for market. It might be interesting to search for the cause of the existing prejudice in France against American pork—a prejudice which prohibits the importation of the American product.

It is true that pork as raised in France and as prepared for market presents a very attractive appearance and is very tasteful, whether fresh or salted, smoked or made into toothsome pâtés by the charcutier. That Americans can produce as good pork and that they can cure it as well as the French is undoubted. Possibly the inferior qualities have more frequently been exported, resulting in unjust prejudice against all American pork.

HORSE MEAT AS FOOD.

The consumption of horse flesh as food has assumed much importance in continental Europe. In Germany, France, and Italy it is a

staple article of traffic. In Paris there are 132 licensed shops where nothing but horse, mule, and asses' meat is sold. In 1888 there were eaten in Paris 17,256 horses, 246 asses, and 43 mules.

In 1856 a book was published in Paris calling attention to various food substances and in particular to horse meat. In this work the author, Geoffroy Saint-Hilaire, in speaking of horse meat, writes: "There are millions of French who do not eat meat, and each month millions of kilograms of good meat are set aside for secondary uses or thrown away as useless." Soon after this some experiments were made on the nutritive and digestive qualities of horse meat, especially at the veterinary school at Alfort. In 1860 unsuccessful efforts were made to establish some horse butcheries in Paris. E. Decroix was very active in promoting the introduction of this food and in 1864 a committee on horse meat was appointed by the Société d'Acclimatation, with Henri Blatin as president and E. Decroix secretary.

For two years the committee were actively at work endeavoring to interest the community in the subject, and in 1866 (July 9) the first horse butcher shop was opened. From that date horse meat has been a regular food among the poorer classes of Paris and the custom has spread to all the large cities of France.

The following table shows the past and present importance of horse meat in Paris:

Year.	Horses.	Asses.	Mules.	Total.	Weight, net.*
1866 (second half)	902	....	....	902	171,380
1867	2,069	59	24	2,152	400,620
1868	2,297	97	11	2,405	443,370
1869	2,622	132	4	2,758	505,540
1870 (first half)	1,904	86	2	1,902	366,440
1870 (second half), siege.. } 1871 (first half), Commune. }	64,362	635	3	63,000	12,261,100
1871 (second half)	1,863	250	17	2,130	367,700
1872	5,034	675	23	5,732	994,580
1873	7,834	1,092	51	8,977	1,552,750
1874	6,659	496	29	7,189	1,295,520
1875	6,448	394	23	6,865	1,249,190
1876	8,693	543	35	9,271	1,685,140
1877	10,008	558	53	10,619	1,939,490
1878	10,800	488	34	11,219	2,082,290
1879	10,281	529	26	10,836	1,982,620
1880	9,012	307	32	9,351	1,732,520
1881	9,293	349	31	9,683	1,789,020
1882	10,891	409	52	13,237	2,906,750
1883	12,776	340	31	9,673	1,789,020
1884	14,548	346	32	14,926	3,297,800
1885	16,506	381	53	16,940	3,744,825
1886	18,051	355	29	18,435	4,085,750
1887	16,203	204	39	16,446	3,664,630
1888	17,256	246	43	17,545	3,930,000
Total	266,342	8,671	677	175,660	54,926,190

*Not including the brain, tongue, liver, heart, kidneys, etc., which are also used for food.

The price of norse meat is about half that of beef; thus, a fillet of beef is sold at retail at 40 to 50 cents per pound and a fillet of horse at 20 to 25 cents, and poorer pieces down to 8 or 10 cents for beef and 4 to 6 cents for horse. It must be remembered in comparing prices in France with those in the United States that the French butchers do not include much bone.

The horse meat shops are located in the poorer quarters of Paris, and the meat being plainly labeled no one is deceived in making purchases. The meat is pronounced more healthy and more nourishing than beef—8 pounds of horse being equal in nutrition to 10 pounds of beef, a fact said to be due greatly to the better food of horses.

A butcher buys ten or fifteen horses in the market and commences by killing those in the best condition and feeds the rest with barley meal and hay and lets them rest until their flesh is in good order.

The present cost of horses used for food is from $12 to $40. They are generally animals unfit for work, not because of disease but for various reasons, such as lameness, or broken down by overwork. Horses too emaciated or diseased are condemned by the inspectors.

A butcher in a shop not far from the Exposition grounds told me that mule meat is more tender than beef. He had a mule's tongue cooking on a little stove for his midday lunch. I did not accept his kind invitation to lunch with him, but on another occasion I purchased a fillet of horse and one of mule and took them to a neighboring restaurant, when I saw them cooked and was able to eat a portion of each. The mule was specially tender and was decidedly sweet—a little too sweet to be thoroughly agreeable, though not at all offensive. The horse meat was not so tender and was dryer, and would perhaps be classed as tough beef. Asses' meat is found still better than mule.

The principal horse market in Paris is on the Boulevard de l'Hospital. Here are sold animals of all grades; the serviceable as well as the unserviceable. Of the unserviceable animals the leather makers take the very thin or sick, while the butchers take the animals suitable for food.

Before being slaughtered the horses must be examined by the inspector, and the carcass, as hung in the butcher shop, always bears the inspector's mark, so there is little danger of unhealthy meat getting into consumption.

I visited the abattoir at Villejuif and saw horses killed and cut up while the butchers waited with their carts to carry the meat to their shops. The killing was done by blindfolding the animal and striking him a blow in the forehead with a heavy hammer. In an instant the horse dropped stunned. The throat was at once cut and the blood allowed to run out and carefully saved, the horse being strung up by a hind foot, so as to hasten the bleeding. After

hanging about a quarter of an hour the skin was removed and the hoofs cut off, the entrails and other internal organs taken out, and the carcass cut in two, beginning at the rear and splitting through the head. To make the skinning easier, the nozzle of a large bellows was inserted under the hide and as much air as possible forced in, so that the flesh was puffed out much the same as in blown veal.

There is little difference in the mode of cooking horse and beef. Stews, soups, roasts, and steaks are made of one as of the other. Horse tongue, heart, brains, and liver are all used as food, and sometimes the kidneys, though the latter generally have a disagreeable taste.

It is doubtless a fact that many sausage-makers use more or less horse meat. In 1873 one establishment in France used the flesh of 500 horses in making sausage.

I translate the substance of the following history of "hippophagie" from a pamphlet by Mon. E. Decroix.*

St. Hilaire states that in nearly every country at some time or other horse meat has been an article of food. In France its use, for religious reasons which do not now exist, was abandoned in the eighth century, and it was not again eaten until the end of the eighteenth century. At that time Parmentier, Baron Larrey, and others called attention to the advantages of horse flesh as food.

The Baron Larrey, in many cases, especially in Egypt, had made good use of horse meat in feeding sick soldiers. The counsels of these men were forgotten. In 1847–'48 Isidore Geoffroy St. Hilaire called the attention of the Société d'Acclimatation of Paris to this question, which a little before that had been raised by Dr. Perner, of Munich.

In 1864 the Société d'Acclimatation organized a special committee to take steps for the encouragement of horse meat as food in Paris by the establishment of butcher shops.

The committee took up subscriptions to enable them to distribute the meat free among the poor. Some dinners were also given, to which were invited members of the press, and which were presided over by eminent men, notably M. de Quatrefages. After two years of constant effort the committee obtained municipal license to open a butcher shop for horse meat on condition that the butcher should have his own slaughter house. The first shop was opened July 9, 1866, and there was plenty of trade. Then a second shop was opened, and a third; in 1869 the number had increased to a dozen or fifteen. During the siege of Paris, in 1870, as beef became scarce and dear it was replaced by horse meat.

The change was very gradual until the new food was very generally used by all classes without any repugnance. Up to the time of the siege there had been considerable prejudice against this meat as an unhealthy, indigestible food, but after the siege the prejudice disappeared and nearly all classes ate it without suffering any inconvenience.

"I believe," says M. Decroix, "that it is unnecessary for me to say more on the qualities of the horse meat. It is healthful and nourishing. It is not always as delicate nor as tender as beef, and this results simply because the cattle are killed young while the horse is slaughtered when at an advanced age, after having been

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*L'Hippophagie et les Viandes Insalubres. Par M. E. Decroix. Extrait du Bulletin de la Société d'Acclimatation, No. d'Avril 1879, Paris, 1879.

long as possible a working animal. In countries where they work cattle the beef is tougher than when they are carefully fattened for food."

It has been difficult to introduce the use of horse meat in England. In 1868 a dinner chiefly of this food was given in London by M. Bicknell, a member of the Société d'Acclimatation; but, as no further efforts were made, it was soon forgotten. In 1875 a French-English dinner was given at the Grand Hotel and the French committee offered a prize of 500 francs to the person who would establish the first butcher shop in London. A Frenchman did start such a shop and kept it open for about 4 months; but, as he did not understand the English language, he was unsuccessful and abandoned the project. In recent years, however, large quantities of horse meat have been eaten in the manufacturing cities of England. It is not sold as "horse," but under the name of "beef."

In Berlin, since 1865 horse meat has been regularly eaten. In Munich the custom began in 1859 and some years later in Vienna.

II.—METHODS OF PRESERVATION.

The various methods of food preservation classified according to their action may be divided into three groups:

(1) The process by desiccation which removes from animal or vegetable substances the water that occasions fermentations or decomposition.

(2) Preservation by antiseptics.

(3) The process by modification of the composition of the surrounding air by cold or heat, by purification or compression, or by an elimination more or less complete.

DESICCATION.

The presence of water in food is one of the conditions necessary to their fermentation and decomposition. Mineral matters do not alter as organic matters, because the former contain no water. Dried vegetables will keep much longer than green ones, because they have lost their moisture. Desiccation may be accomplished either by exposure to the sun and air or by means of artificial heat. Preservation of meats by drying is a very ancient method, and it is still practiced all over the world. In South America, and among the Indians of North America, as also in Africa and in Scandinavia, and throughout China and Asia, meat and fish are preserved by simply drying.

The simplest method of desiccation, and that employed by the aborigines in America and other countries, consists in dividing the meat into long strips and exposing them to the action of the air and sun. In Norway fish are thus hung on bars and left in the cool, dry, open air for months, when they have become hard and almost

entirely free from moisture. In some countries the slices of meat are sprinkled with corn meal and are sheltered from rain and the dews of night. When dried these bands of meat have lost about three-fourths their weight.

The preparations of *tasajo* exhibited by the Argentine Republic, Uruguay, and some other South American nations, are made essentially by the above method. It is unsightly to say the least. The *tasajo* is, however, heavily salted and is submitted to pressure in piles before exposure to the air. In this respect it is the same as the common salted dry codfish so common throughout North America and Europe. It is largely eaten by the poorer classes. A piece needed for a day's food is soaked for several hours in fresh water and is then boiled as ordinary meat.

The beef of Brazil, though good, is less savory than European meat. The same statement will apply to all South American beef. It is cheap at Rio Janeiro, selling at retail on an average at 20 cents per kilogram. Great quantities are eaten fresh in Brazil. There is also consumed a very great quantity of preserved meat, known under the name of *xarque* or *carne secca* (dried meat) prepared at Rio Grande do Sul, chiefly in the city of Pelotas, which owes its prosperity entirely to this industry. The cattle arrive here in large herds during the six months from December to May, and about 400,000 cattle are then annually prepared as dried meat. At the slaughterhouses they are killed by plunging a long knife into the neck. This operation does not at once kill them, but deprives them of all sensibility, so that they fall to the ground. The operation lasts not more than a minute, and often in one establishment six to seven hundred cattle are killed in a day. After slaughtering the hide is promptly removed, taking care to plunge a knife into the heart while it still beats, and the flesh is separated from the bones and cut into eight pieces, that are placed on the tables. These pieces are then cut into strips about 15 millimeters thick, which are sprinkled with salt and stacked in piles several meters in height. Care is taken to spread sufficient salt between the successive layers of meat. In this way the meat becomes impregnated with salt. The next day the strips are repiled, the lower layers being placed on top. In one or two days the strips are taken from the pile and hung in the air to dry. When the drying is completed the meat has the appearance of great strips of old leather of yellowish color. It is shipped without the least packing and will keep for a long time. It is consumed in enormous quantities in Brazil, and in the Argentine Republic and Uruguay, where it is also made in large quantities. The island of Cuba imports a large amount of inferior quality. The dried meat is at first distasteful to foreigners, but after a time they become accustomed to the taste. It is a healthy and nutritious food, and cheap. At Rio de Janeiro where fresh beef is about 20 cents per kilogram the

dried beef is only 5 cents higher, though the latter contains very much more nourishment.

In Europe meat is sometimes dried by placing it in a heated chamber for 48 to 72 hours at a temperature of about 150° F. The meat, which has by this time lost all of its moisture, is plunged in a strong gelatinous solution and dried again for a few hours. Meat thus preserved will keep for many years. To prepare it for eating the gelatine is washed off and the meat soaked in tepid water.

Meat thoroughly dried may be pulverized into a powder, a method employed for very many years.

A kind of soup bread was exhibited, made from a mixture of equal weights of hashed meat and flour. The paste is leavened and baked. A good soup may be made from it by an addition of water and a little salt.

Soup tablets were shown in the French and English sections. They are made from meat juice by a rapid concentration and evaporation, reducing the juice to a sort of thick paste. The French generally use in making these tablets nearly equal parts of beef and mutton and a quantity one-fourth less of veal fillet, to which they add some calves' feet. This mixture is boiled slowly and after it has been cooled is skimmed and clarified with the whites of eggs and evaporated to a suitable consistency to be made into tablets. To make soup, the tablets are diluted with thirty times their weight of water. To avoid a gluey taste M. Martin employs the following process: The bouillon is evaporated slowly in a steam jacket kettle, the temperature being raised to about 120° F. When reduced to a sirup it is put in tin boxes which are at once hermetically sealed. The boxes are then put in boiling water for a half hour to destrov all germs of fermentation.

The Russians make a concentrated bouillon which is sold in solid disks and which makes an excellent soup, much superior to the tablets in taste and nutritive value. In preparing disks they submit quarters of beef to a long boiling. The greasy matter is removed, and when the evaporation is far enough advanced the paste is set to cool in shallow molds.

Extract of meat, commonly called Liebeg's extract, is now very extensively prepared in South America, in the United States, and in other countries. There were several large exhibits of this food.

PRESERVATION BY ISOLATION OR BY ANTISEPTICS.

The object to be accomplished in preservation by isolation is to put the subject to be preserved outside the ordinary conditions of fermentation either by killing the ferment germs or by checking their action. When the preserving agents employed do not impart an unpleasant taste to the food, isolation is perhaps the simplest and best process of preservation. Antiseptics have the property of pre-

venting the decomposition of organic matter either by preventing the injurious action of the oxygen or of the water, the presence of which, according to Guy-Lussac, is necessary to all fermentation, or the antiseptics destroy the action of the ferments, which, according to M. Pasteur, are the essential cause of the decomposition.

Antiseptics also act upon the organic substances either in coagulating their albumen, or in absorbing the products of putrefaction. Some antiseptics, as the metallic salts, combine directly with organic matter.

An important method of preventing decomposition of animal flesh is the application of antiseptic salts in a powdered form to the surface of the substance or to impregnate it with a solution either by atmospheric or hydraulic pressure. Among the commonest and most effective antiseptics, exclusive of chloride of sodium (common salt), are acetic acid, as contained in vinegar, and boracic acid. The latter preservative has come into favor in the preparation of fishery products, because of its very satisfactory properties. As compounded with salt in the form of a powder or in solution with tartaric acid, boracic acid is found to effectually preserve either dry or pickled fish in good condition for a long time.

At the Fisheries Exhibition, at London, in 1883, some Pacific salmon were shown which had been packed in a solution of boracic acid and other ingredients for several weeks, and after their long land and water journey they were removed from the solution and exposed to the atmosphere at the fish market for several days, still retaining most of their original flavor and freshness.

At the Centennial Exposition at Philadelphia, in 1876, there were some exhibits of fresh oysters and clams preserved in chemical liquids, and which the juries on awards pronounced of good quality. Boracic acid was reported to preserve animal matter for several months without changing the texture as common salt does. Citric and acetic acids also proved good preservatives, and fish cured in these acids were, after a little soaking in fresh water, found free from all unpleasant flavor.

In Portugal, fish are kept fresh for a considerable time by removing the viscera and sprinkling the abdominal cavity with sugar, when they are hung up to allow the sugar to impregnate the flesh as much as possible.

Lobsters, oysters, oyster crabs, mussels, scallops and some other marine products are preserved in vinegar alone, and, packed in glass jars, are common in the New York markets under the name of "pickled" products. Herring, mackerel, and other fish are largely prepared with compounds of vinegar and spices and sold as Russian sardines, marinated fish, soused fish, and by other trade names. The preparation of Russian sardines from the common sea herring was introduced into England by some enterprising New York

merchants during the Franco-Prussian war. The principal seat of operations was Eastport, Maine, and the methods employed as patented in 1875 by Messrs. Sellman, Reessing, and Wolff, have been as follows: The fish while alive are thrown into strong brine contained in suitable casks on board the fishing vessels. This part of the process is important, as it not only kills the fish but prevents them from spoiling while being cleaned and cured. After being kept in the brine for at least ten days they are beheaded, gutted, scaled, and are thoroughly cleaned in clear, cold water and placed in large willow baskets or in sieves to drain off the superfluous water. In five or six hours they are spread upon packing tables and assorted as to size, each size being packed by themselves.

The fish are preserved and at the same time flavored by being packed with the following ingredients, the quantities given being for 120 pounds of fish: Two gallons vinegar, $1\frac{1}{2}$ pounds allspice, 2 ounces pepper, 4 pounds sliced onions, 2 pounds sliced horse-radish, 1 pound bay leaves, one-half pound cloves, one-half pound ginger, one-half pound coriander seed, one-fourth pound Chile pepper, and $2\frac{1}{4}$ ounces capers.

In packing the fish a small quantity of vinegar and a thin layer of the other ingredients are placed in the bottom of the vessel, and a layer of fish, placed back upward, is put in and gently pressed down. Another small quantity of vinegar and thin layer of the other ingredients are put in and another layer of fish, and so on until the vessel is full. The fish are ready for market and consumption in about four days in summer and from three to four weeks in winter.

Soused mackerel and other fish may be prepared as follows: The fish are cut into pieces about 2 inches long and cleaned. A souce is made of cider vinegar and cloves, nutmeg or other spices, with parsley, bay leaf, and onions, and the fish are immersed in this souse for twelve hours, when they are put in a second souse, made the same as the first with the addition of capers, olive oil, Worcestershire sauce, and extract of anchovy and lemons. After remaining in the second souse for ten hours, they are heated in the souse for four to eight hours at about 140° F., and are then packed with the souse in air-tight pots or jars.

Acetic acid in its concentrated form or diluted with water in the form of vinegar is much used as a preservative agent. Thus fish to be preserved are put in barrels, or other packages, with a liquid composed of acetic acid and carbonate of soda in sufficient quantities to make a slightly acid solution of acetate of soda, to which is added enough water to give the liquid a density of 3 to 5 degrees. A few grains of salt may be added to give an agreeable taste, and about 5 drops of nitrate of soda for each pound of the liquid to preserve the color of the substance. Prepared chalk may be used instead of car-

bonate of soda. The fish may be kept in this solution, or after being saturated with a denser liquid may be dried.

In the United States, until within a very few years, little advantage has been taken of the effective preservative power of boracic acid in combination with common salt. In 1883 the writer found that at Gloucester, Massachusetts, the headquarters in this country for the curing of dry-salted fish, the use of boracic acid was just begun, and then only by a few curers. Since that date, however, "Preservaline" and other chemical powders having the above substances as their base have come into quite general use, particularly in the warmer months, when without this preservative it is often found impossible to keep dry fish in good condition for many weeks or even days. This powder checks the peculiar reddening so commonly seen on dry-salted fish in summer.

The chemical powder used by the Norwegians in preserving fresh herring for export is a mixture of boracic acid and salt, using about two pounds of salt to each pound of boracic acid. Herring are packed in barrels in the ordinary methods with alternate layers of fish and powder, and after the barrel is headed they are "pickeled" with a weak solution of pure boracic acid. Fish preserved in this way will keep perfectly fresh and of their natural flavor for a week or even longer. The Norwegians have in some seasons profitably competed with Scotland in supplying the London market with fresh herring thus prepared. A more complete preservation of herring, so that they will keep in good order for a long time, is obtained by the Sahlstrom process and by the Roosen method, by which a solution of boracic acid and salt is thoroughly impregnated into the flesh under a pressure of 60 to 100 pounds to the square inch. Successful experiments have been made in Scotland in treating fresh salmon by the Roosen process. Three hundred pounds of fish were packed in a strong steel barrel and with a pressure pump the solution was forced into the salmon until they were thoroughly impregnated. After three weeks subjection to this process the fish were cooked and found of excellent flavor. Strongly made wooden barrels may be substituted for steel barrels, or, after being treated under pressure, the fish may be repacked with the solution in common fish barrels.

By Eckhart's process, devised by John Eckhart, of Munich, and patented in 1880–'82, fish are prepared in a preserving salt consisting of a mixture of 50 per cent common salt, 47½ per cent chemically pure boracic acid, 2 per cent tartaric acid, and ½ per cent salicylic acid. The fish are first stripped of skin and bones, and the flesh is mixed with the preservative in the proportion of 20 grams of the mixture to 1 kilogram of fish flesh. They are then packed in cases of parchment or other material and put into casks which are filled with a gelatine solution made in the proportion of 50 grams of gela-

tine, 20 grams of the preservative, and 1,000 grams of water. The casks are then headed and connected with a force pump and more of the solution is forced in until the contents are well saturated. The sacks or cases of fish are then removed from the cask and may be strewn over with more of the salt in dry condition and packed for shipment, or they may be shipped in casks with the liquid.

By the Am Ende process boracic acid, either in a liquid or pulverous state, is compounded with acetic acid in the proportion of about one drop of acetic to every ounce of boracic acid, and the compound is applied in the usual manner. The acetic acid is said to prevent the formation of fungi, while the boracic acid prevents putrefaction by hindering the formation of bacteria.

The process devised by Hugo Jannash consists in subjecting meat or fish to a compound prepared of chloride of potassium, nitrate of soda, and chemically-pure boracic acid, which ingredients are dissolved in water, then mixed under exposure of heat, thus forming an antiseptic salt composed of hyponitrate of potash, hypochlorate of soda, borate of soda, borate of potash, and free boracic acid. The compound is applied either as a salt or in a more or less strong solution, according to the time for which the fish are to be preserved.

By the Herzen preserving process meat is soaked for twenty-four to thirty-six hours in a solution of 3 parts of borax, 2 of boracic acid, 3 of saltpeter, and 1 of salt, in 100 parts of water, and then packed in some of the solution. Before use the meat must be soaked twenty-four hours in fresh water.

Preservation by sulphurous acid is a simple and effective method of keeping meat for a few weeks, although the rather unsightly appearance of the meat thus treated appears to prevent its general use. All that is necessary in this process is to subject the meat to the fumes of burning sulphur for fifteen or twenty minutes. For preserving vegetable substances, the sulphur process appears to be specially adapted, as most of their water is thus absorbed.

Carbolic acid, pyroligneous acid, and salicylic acid have been used to preserve meat, but they produce a disagreeable taste, and there is also a question as to their injurious action on the health. In France the use of salicylic acid as a food preservative has been forbidden by law.

By the process of Dr. Sace, of Switzerland, meat is immersed for twenty-four hours in lukewarm water, mixed with salts of ammonia in the proportion of 10 grams of salt to a liter of water. The meat is then packed in barrels and covered with powdered acetate of soda. In twenty-four hours the acetate has absorbed the water and the meat is repacked in reverse order and more soda added, and after some hours the curing is complete. Entire animals, game, fowl, and fish have been preserved by this method after having been eviscerated, and their flavor is said to be well retained. The same process is appli-

cable to vegetables, but they are first immersed for a few minutes in boiling water, and, after applying the acetate of soda, are dried in the open air or in an oven.

The antiputrid properties of wood charcoal have been utilized as a preservative, the pieces of meat being wrapped in fine linen and placed between layers of charcoal.

The process of subjecting meat or fish to the action of wood smoke is properly preservative by antiseptics. It is one of the oldest methods of preserving food, and one universally employed throughout the world. Meat is usually salted, generally with the addition of saltpeter, before being smoked. The kind of wood employed affects the flavor.

In smoking hams, the fire is usually in the basement of the building and the smoke chambers on the third floors, so that the smoke has become partially cooled before acting on the meat.

A pickle made of common salt and saltpeter is a very common preservative. It is usually made in the proportion of 15 to 20 parts of salt to 1 or 2 of saltpeter, for curing meats that are to be smoked, sometimes with the addition of salts of ammonia and brown sugar. In making the liquid pickle, the English take 100 parts of water, 3 parts marine salt, one-half part saltpeter, and 2 parts brown sugar. This solution is boiled for an hour and strained before using. The Russians take water enough to cover the meat, and add salt, brown sugar, and molasses. An aromatic pickle is made from 2 parts water, 1 part marine salt, 8 grams coriander, 4 grams mace, 10 bay leaves, a pinch of aromatic herbs, and a little ginger.

The old French method of salting pork is to pack the pieces in a vessel with a layer of salt in the bottom, then the hams and other pieces are well sprinkled with salt and the vessel is filled with alternate layers of pork and salt. By the present method employed at Paris, the breasts and hams are packed in brine for ten to twelve days in stone troughs, much care being taken in the selection of pure and good salt. In Lyon, Rouen, Nantes, and some other cities of France, they have processes differing more or less from the last.

In the north of France the pork freshly killed is cut up and the hams and shoulders are set aside for salting and smoking, and the head, feet, and tripe are sold fresh. Before salting, the meat is carefully washed in fresh water and is then wrapped in white linen towels and put in the salt vats. Pieces of poor quality are put in the bottom, medium grades next, and the best at the top, all being closely packed to leave as few spaces as possible, and kept down by heavy weights. The pork is left in pickle for a month or six weeks. If for home consumption the pieces are then put in boiling water and quickly taken out, washed, dried, and smoked.

If to be kept for some time, the hams taken from the salting vats are plunged into cold water for two or three hours to remove the salt,

after which they are wiped and promptly dried. Hams of 6 to 7 kilograms weight remain in pickle about five weeks, those 7 to 12 kilograms six weeks, and those 12 to 20 kilograms seven weeks.

There were some attractive exhibits of pork products, especially in the French and English sections, The English hams appeared to be well cured and were in very good condition, even after four or five months' exposure in the show cases. Bacon and hogs' heads were shown by several English firms. The great variety of preparations of pork meat, salted, smoked, and made up into sausages and meat pies neatly arranged and decorated in a tasteful manner by the skillful French charcutiers were much admired by visitors. In preparing hams in France they are sprinkled with salt and saltpeter in the proportion of 10 parts salt to 1 part saltpeter (by weight) and are then pressed for two or three days. They are then sprinkled again with salt and saltpeter, and left for some weeks in brine, and then re-pressed and resalted. After two or three days they are smoked. Oak and juniper wood are the woods commonly employed to produce the smoke. After the smoking is completed they are wrapped in sacks and hung in dry, dark rooms. Sometimes, instead of leaving the hams in brine for several weeks, they are wrapped in cloth and buried in dry earth and taken out for a few hours each week to be sprinkled with salt.

The "hams of Westphalia" are cured in pure saltpeter and submitted to pressure for eight days. They are then packed for a day in brandy flavored with juniper berries and after drying are smoked with juniper wood.

Bayonne hams are soaked in a solution made of dregs of wine and water in equal parts, salt and saltpeter in proportion of 10 to 1, laurel, juniper, thyme, sage, and coriander.

In Alsace the hams are flavored with white wine and water to which are added salt and aromatic herbs.

The hams of Mayence are smoked for a long time.

In the preparation of French sausages, to make the meat they take the neck, the head, and the throat of the hog, being careful to remove muscles and nerves from the flesh in mixing the fat with the lean portions. With 5 kilograms of meat they mix 100 grams of fine salt, a teaspoonful of pepper, and some spices. This seasoning is added at the commencement of hashing, so that it may become thoroughly mixed with the meat. The spices usually consist, in a total of 500 grams ($1\frac{1}{10}$ pounds), of 350 grams pimento and 50 grams each of nutmeg, cloves, and cinnamon. Sometimes there is added 10 grams each of thyme, laurel, marjoram, and rosemary. These herbs are well dried and are ground up in a mortar. A common flavoring consists of a mixture of parsley, thyme, and laurel, and frequently flavoring is made with carrots, onions, and parsnips.

The sausage known as "Paris sausage" is made of very tender pork meat of the best quality, seasoned with salt, ground pepper, pepper in grains, spices, and white sugar.

Sausage cases are the intestines of either hog or sheep, the stuffing being generally done by machines of which there were many on exhibition, but these as well as the hashing machines showed no improvement worthy of attention in comparison with our American apparatus.

Truffle and pistache sausages are made with ordinary sausage meat by adding to 5 kilograms of meat 100 grams of pistache parings and 500 grams of peeled truffles.

The so-called imperial sausage of liver with truffles and pistache is made as follows: For 6 kilograms of ordinary sausage meat 2 kilograms lean pork or veal are mixed with 500 grams of cooked Bayonne ham and 1 kilogram of fresh fat pork. After these are well hashed there is added 500 grams of liver, three or four yolks of eggs, with 125 grams of fine salt, white pepper, and four spices. There is then added a small glass of good curaçao.

The Lyon sausages are made entirely from pork meat, especially from the hams. To 10 kilograms of the meat when half hashed there is added 500 grams of salt, 30 grams of pepper, 20 grams of four spices (pimento, nutmeg, cloves, and cinnamon) 5 grams of powdered sugar, 15 grams of pepper in grains, and two small glasses of curaçoa. To this paste is added 1.5 kilograms of fat pork cut in small squares.

Strasbourg sausages are made with half pork and half beef.

The Brunswick sausages are made of pork meat half lean and half fat. When put in the cases it is smoked with fragrant herbs.

There were many other varieties of sausages exhibited, but there is nothing new in their fabrication, and it seems unnecessary to mention them here. Neither shall I discuss the details of making the very numerous kinds of sausage puddings, preparations of hogshead cheese, liver, tongues of beef, hog, and veal, pigs' feet, sheep's feet, fowl, game, etc., all of which were exhibited and recipes for which will be found in any cook-book.

MISCELLANEOUS PRESERVATIVES.

Butter and other fats are used as preservatives for delicate meats, as fowl, etc. There were some excellent exhibits of products thus preserved.

Preservation by oil is applied especially to cooked meats and fish, as in the case of sardines.

Meat will keep perfectly fresh for a week or more in curdled milk. This method is much employed in Alsace-Loraine.

Honey can also be used as a preservative, although it is rather an expensive process to use a pound of honey to keep a pound of meat.

Meat immersed in paraffine at a temperature of 220° F. until it is reduced one-half in bulk will be preserved so as to keep for a long time, though it requires much patience to eradicate the disagreeable flavor.

A mixture of bisulphate of alumina and nitric acid is sometimes used as a preservative and disinfectant of blood and other refuse of the slaughter houses.

Oysters, fish, meats, etc., may be preserved by the use of a mixture of glycerine with phosphate of soda or other antiseptic salt in connection with aldehyde, formic ether, or acid, in a solution of carbonic acid, water, glycerine, etc., and the preserved substance is then covered with paraffine or stearine.

Among the many other chemical compounds that have been experimented with, and some of which have been successfully used in the commercial preservation of animal flesh, may be mentioned :

(1) A solution of gelatine and bisulphite of lime forced under pressure.

(2) Fish flesh ground into fine pieces, pressed, moistened with glycerine, and wrapped in tinfoil.

(3) A solution of saltpeter and alum in proportion of 5 pounds of saltpeter and 4 ounces of alum to 60 gallons of seawater.

(4) A solution of thymol, thymic acid, or any of the thymate salts and water, alcohol, or glycerine.

(5) Acetate of lime solution in water at a density of six degrees by the aerometer, to which is added acetic acid of eight degrees, so that the liquid will produce sensible acid reaction upon blue reaction paper.

(6) Sulphite of soda and carbolic acid in solution in proportion of 5 gallons water, 2 pounds sulphite of soda, and 2 ounces carbolic acid.

(7) Hydrocarbon substituted for the air, which occupies the space in and around the substance to be preserved and subjecting the same to a temperature of about 30° F., the gas entering by a hole at the top and the air escaping through a hole in the bottom of the package.

(8) A solution of salicylic acid dissolved in water, with which the fish is impregnated under hydraulic pressure.

(9) Salicylic acid dissolved in hot glycerine and mixed with hot water. Preserving cans are coated on the inside with the above solution; then the fish are hermetically sealed in the ordinary manner.

(10) A brine or composition for preserving fish, meat, etc., consisting of a solution of starch, sugar, or glucose and common salt.

(11) Fish are packed in a dry powder of gypsum and carbon and then enveloped with plastic shell, composed of gypsum, carbon, silicate of soda, and water.

PRESERVATION BY MODIFICATION OR EXCLUSION OF THE AIR.

REFRIGERATION—CANNING.

The composition of the surrounding atmosphere may be modified by heat, by cold, or by compression, so as to hold in check the destructive germs of ferment, or the air may be partially or wholly eliminated as in the Appert process.

The process by heat and by compression are not much employed. By the Danet process the meat or other substance to be preserved is put in a closed chamber filled with air deprived of its oxygen by being subjected to heat from gas jets.

Air compressed to 4 or 5 atmospheres checks the action of ferment germs and consequently prevents decomposition of food substances. The fact that cold air checks decomposition is put to practical use by packing food in snow or ice or in air reduced to a low temperature.

In recent years there has been a very great development in the application of refrigeration in many food industries. An enormous traffic is now carried on in foods preserved for months in cold-storage warehouses, and meat and fish in fresh condition are now transported for thousands of miles by rail and by sea. It is only the expense of freight that prevents an extensive trade in fresh salmon sent from the Columbia River in Oregon to European cities. Australian and South American meats have become staple foods in Europe, and in England fresh beef from the United States competes in quality with the home product.

Some foods, as fresh fish, keep in better condition when frozen solid, and beef is often thus preserved; but it has been found that meat keeps its flavor better if kept at a temperature a little above the freezing point.

The cold air must be dry to insure the best results, and to secure just the proper degree of temperature and the requisite dryness is the aim of the manufacturers of refrigerators and refrigerating machines.

There were at the Paris Exposition many excellent machines for refrigeration dependent upon the properties of various chemicals of absorbing heat.

We have in the United States the application of many systems of refrigeration. One of the cold-storage warehouses in Boston has immense chambers on the top floor filled with ice and the cold air from the ice is conducted by systems of pipes and ventilators to the floors below, where are stored immense quantities of all kinds of provisions. Most of the refrigerator cars carrying beef and other products from the West to the seaboard are built on the same general plan as the above warehouse. In most of the great cold-storage

warehouses of the United States and Europe the low temperature is produced by refrigerating machines. A common and effective system is the circulation of cold brine through pipes traversing the storage rooms. The brine is reduced to the desired temperature by the powerful compression and condensation of ammonia gas which is then reëxpanded in a coil of pipes surrounded with brine. In the process of reëxpansion the gas extracts heat from the brine, which, thus cooled, is pumped through pipes in refrigerating chambers and cools the air as described in detail on subsequent pages of this chapter.

Air filtered through cotton-wool is free from ferment germs. In air thus purified, blood and other highly perishable liquids have been kept good for a considerable time.

EXCLUSION OF AIR.

The Appert process of preservation is perhaps the most important method of keeping food in good condition for long periods. It is based on the principle that, "when an animal or vegetable substance is inclosed in a vessel hermetically sealed and submitted to a temperature of more than 212° F., it decomposes the atmospheric air contained in the vessel, absorbs the oxygen, and becomes by the absorption completely and indefinitely imperishable." The principle was little known or at least little appreciated until Nicholas Appert* in 1804 first put his process into practical use. In 1806 he clearly established the value of his discovery by a series of trials made at Brest by order of the French government. It was during the Crimean war that this process was first extensively employed.

The principal operations in the Appert process are: (1) Place the substance to be preserved in bottles or jars or in tin boxes. (2) Cork or solder the vessel with great care. (3) Submit the substances thus inclosed to the action of boiling water for a greater or less time, according to their nature.

The improved closed boilers now employed permit the third operation to be so controlled by steam gauge and thermometers that meats, fish, vegetables, and fruits may each be subjected to proper pressure and heat.

There are three chief modifications of the canning process: (1) Aberdeen; (2) steam retort; (3) chloride of calcium bath. The Aberdeen process originated with Appert. The meat is put in vessels nearly closed; these are then put into a close boiler, and the heat raised to 112° (234° F.). After about 3 hours cooking the ves-

* Appert died in 1841. The history of this process is well told in the biography of Appert by Felix Potin in the French report of the International Jury of Group VII, Exposition of 1889. Paris, 1891.

sels are hermetically sealed. McCall's improvement is the addition of a little sulphate of soda. Another improvement is to drive the water off at 230° F. *in vacuo* and the heat is then raised to, and kept at, 270° F. The special feature is the vacuum, all the oxygen being extracted by means of tubes connecting the tins with the vacuum chamber; this greatly reduces the time.

By the steam-retort plan, the meat is placed in cans with a pin hole in the top, and the cans are put into a retort under steam at 230° F. and left there for 1½ to 2 hours; they are then taken out, and the pin holes are soldered up while steam is issuing from them. The cans are again steamed at 240° F. and cooled. The object of the chloride of calcium bath is to obtain a higher temperature. The raw meat is put into cans having a pin hole, as before. The cans are placed for half their depth in a solution of chloride of calcium. The heat is gradually raised from 180° F. to 230° F. and the steam is allowed to blow off for four hours, during which time the meat is being cooked. The holes are then closed by a drop of solder, the heat is raised to 260° or 270° F. for half an hour, and the cans are withdrawn and cooled.

Only a very few of the many modifications of Appert's process were represented at the Exposition except by the products themselves.

By the process of M. Fastier the air is entirely removed from the boxes or jars containing the food. The temperature of the water bath is raised to 110° C., adding to the water a mixture of sugar and marine salt. At this temperature the liquids in the box will boil. At this moment the steam and with it the air in the box is allowed to escape through a little hole, which is then soldered up.

III.—ARTIFICIAL ICE.

The manufacture of ice has during the last 10 years become a very important industry in many countries, even where natural ice may be procured at reasonable prices, for the artificial product may be prepared in any desired form and from pure water, so that it is marketed in direct competition with natural ice.

Numerous ice-making and refrigerating machines were shown at the Exposition in the French, Belgian, and Swiss sections, and two systems of English make were exhibited. There were no American machines shown, though many are manufactured in the United States in some respects superior to those of European make.*

It does not seem necessary here to repeat the history of the ice industry and of refrigeration as applied to food preservation, for the

*Among the American manufacturers to whom I am specially indebted for information concerning ice-machines are the De la Vergne Company, of New York, and the Frick Company, of Waynesboro, Pennsylvania.

question is elaborately discussed in the reports of the United States Commissioners to the Paris Exposition of 1867, and in the valuable trade pamphlets published by the more important ice-machine manufacturers in the United States.

Three methods are commercially employed to convert water into ice: (1) By compressed air, (2) by evaporation of volatile liquids, and (3) by the employment of refrigerating mixtures.

The method by compression of air requires excessive mechanical force and is generally considered an expensive process.

It is much easier to produce cold by evaporation of liquids than by compressed air, and this method with various modifications is now most commonly employed. The principal chemicals used are anhydrous ammonia and anhydrous sulphurous acid. Refrigerating mixtures owe their action to the changing of a solid into a liquid.

A mixture of common salt and ice creates a low temperature, and so the mixtures of various other chemicals enumerated below have been used either commercially or experimentally as freezing mixtures.

The artificial production of ice or refrigeration consists in transferring the heat of the water (or other body to be frozen) to some other body. At 60° F. water contains an excess of heat beyond that of an equal weight of ice at 32°, amounting to 170.65 heat units for each pound; therefore to reduce the water from the first temperature to the second necessitates the extraction of that amount of heat from it. To reduce 1 ton of water will require the removal of 62720 heat units or 2,240 pounds by 28 (the difference between 32° and 60° F.). It would still be water. To convert it into ice it is further necessary to extract the latent heat, which determines the liquid state of water, amounting to 142.65 heat units for each pound of water or 319,536 heat units for one ton, bringing the total to 382,256 heat units. It is evident from this that about five times a greater expenditure of power is necessary to transform water at the freezing point into a solid condition (ice) than is necessary to reduce its temperature from the ordinary point to the freezing point; and this fact must be borne in mind in the practical application of refrigeration to commercial purposes, where a low temperature will often be as effective as the actual production of ice.—(*Spon.*)

In the use of "freezing mixtures" the reduction of temperature in the body is due to the absorption of its heat by the process of solution suffered by the salts employed. Some such mixtures are the following:

	Temperature sinks degrees F.	Actual reduction.
	° °	°
(1) 2 parts snow or powdered ice, 1 part common salt	to − 5	
(2) 5 parts snow or powdered ice, 2 parts common salt, 1 part ammonium chloride	to −12	
(3) 24 parts snow or powdered ice, 10 parts common salt, 5 parts ammonium chloride, 5 parts potassium nitrate	to −18	
(4) 12 parts snow or powdered ice, 5 parts common salt, 5 parts ammonium nitrate	to −25	
(5) 1 part ammonium nitrate, 1 part water	40 to 4	36
(6) 5 parts ammonium chloride, 5 parts potassium nitrate, 16 parts water	50 to 10	40
(7) 5 parts ammonium chloride, 5 parts potassium nitrate, 8 parts sodium sulphate, 16 parts water	50 to 4	46
(8) 5 parts sodium sulphate, 4 parts dilute sulphuric acid	50 to − 3	53
(10) 3 parts snow, 2 parts dilute sulphuric acid	32 to −23	55
(11) 1 part ammonium nitrate, 1 part sodium carbonate, 1 part water	50 to − 7	57
(12) 8 parts snow, 5 parts hydrochloric acid	32 to −27	59
(13) 6 parts sodium sulphate, 4 parts ammonium chloride, 2 parts potassium nitrate, 4 parts dilute nitric acid	50 to −10	60
(14) 9 parts sodium phosphate, 4 parts dilute nitric acid	50 to −12	62
(15) 7 parts snow, 4 parts dilute nitric acid	32 to −30	62
(16) 4 parts snow, 5 parts calcium chloride	32 to −40	72
(17) 2 parts snow, 3 parts crystallized calcium chloride	32 to −50	82
(18) 3 parts snow, 4 parts potash	32 to −51	83
(19) 6 parts sodium sulphate, 5 parts ammonium nitrates, 4 parts dilute nitric acid	50 to −40	90

The above mixtures are useful on a small scale, but not for commercial operations. In selecting mixtures for extensive use it is necessary to consider several points: (1) The amount of latent heat absorbed by 1 pound of the body in changing its state is 966.1 heat units for watery vapors, 900 for gaseous ammonia, 364.3 for alcohol vapor, and 162.8 for ether vapor. The amount of artificial cold produced will be in inverse ratio—thus, to make 1 ton of ice will require the vaporization of 395⅗ pounds of water, 424⅘ pounds of liquid ammonia, 1049¼ pounds of alcohol, or 2,348 pounds of ether. (2) The next point to consider is the degree of facility with which the bodies are vaporized and the range of temperature within which this can be readily accomplished, that is to say, the boiling point of the body and the tension of its vapor. It is sought to obtain a body having the former as low as is convenient, combined with the latter moderately low. Many difficulties by selecting bodies possessing the former quality without much regard to the latter. Thus, at a temperature of 75° F., which is often exceeded in town waters in warm countries, the tension of liquid ammonia will be 150 to 160 pounds a square inch; chloride of methyl, about 80 pounds; methylic ether, 78 pounds; sulphur dioxide (sulphurous anhydride or oxide), 60 pounds. These immense pressures necessitate extreme care in the construction of apparatus, thereby enhancing the cost; and the difficulty of keeping

the joints tight often occasions loss of material and reduced production. (3) Equally necessary to be considered is the condensation of the vaporized body, in order that it may be used over again. This condensation is effected by means of a supply of cold water. In some industries, and in certain localities, the scale of consumption of water for this purpose is such as to altogether preclude the use of certain machines. (4) The chemical properties of the substances employed must be studied in relation to their action upon the metal or other material with which they will come into contact.

A machine of English manufacture worked by compressed air was exhibited in the Argentine Republic Pavilion and appeared to do its work well. It was in operation all summer, being specially used to supply cold air to a large refrigerator filled with South American fresh meats. The machine was made by J. & E. Hall, Dartford, Kent, England, and is illustrated in Plate LII. The manufacturers have furnished numbers of these machines for service on vessels in the carrying trade between South America and Europe.

Whatever be the refrigerating or heat absorbing agent used, whether ammonia, ether, sulphurous oxide, or other chemical, the essential steps in the operation are the same, namely, (1) compression; (2) condensation; (3) expansion.

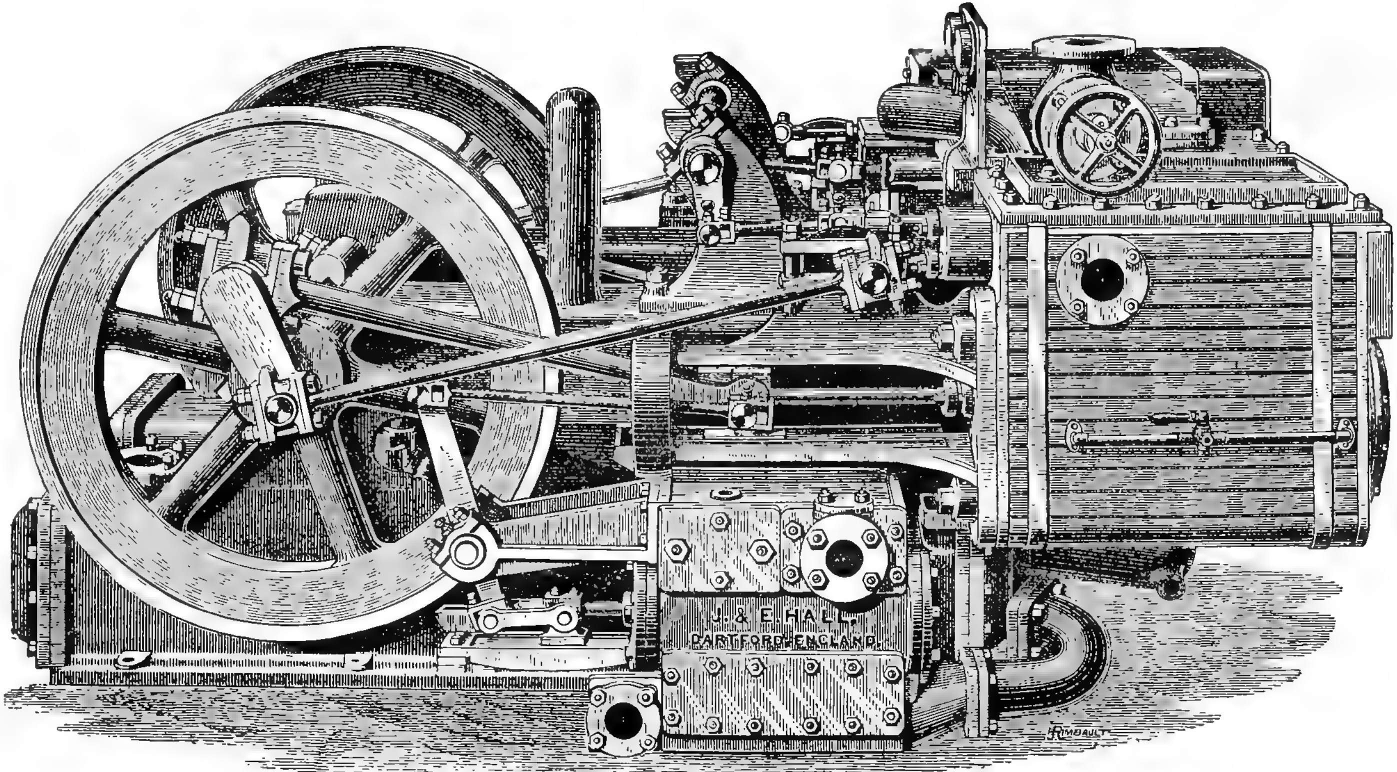
The agent in gaseous form is compressed either mechanically or otherwise to prepare it for the second operation. The pressure in the case of ammonia varies from 125 to 175 pounds per square inch, according to the temperature of the condensing water used. During the compression heat is developed in proportion to the degree of pressure exerted or to the relative volume to which the gas is reduced.

The heat in the gas by compression is withdrawn in the operation of condensation by forcing the gas through coils of pipe while the coils are in contact with cold water, the heat being taken up by the water and the gas assumes a liquid condition.

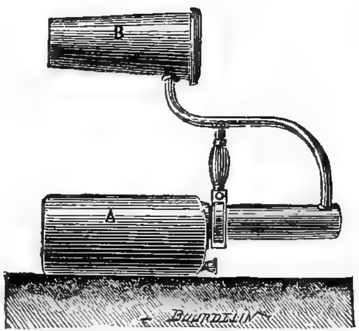
The liquefied gas is then allowed to enter coils of pipe so arranged that the substances to be cooled (air, water, brine, etc.) can be brought into contact with them, the pressure in the interior of the coils being maintained at a lower point than that required for retaining the gas in a liquid state. The liquefied gas, upon entering the coils, reëxpands and extracts from the substances surrounding the pipes the same quantity of heat that was given up by the gas to the water in the operation of condensing and liquefying.

The gas having completed its work again passes through the three operations, and so the cycle may be continued indefinitely with the same gas.

These principles are common to most of the ice machines now in use, but the apparatus employed to compress the gas and to facilitate its liquefaction and reëxpansion permit of many ingenious modifications.



REFRIGERATING MACHINE. HALL'S SYSTEM BY COMPRESSED AIR.



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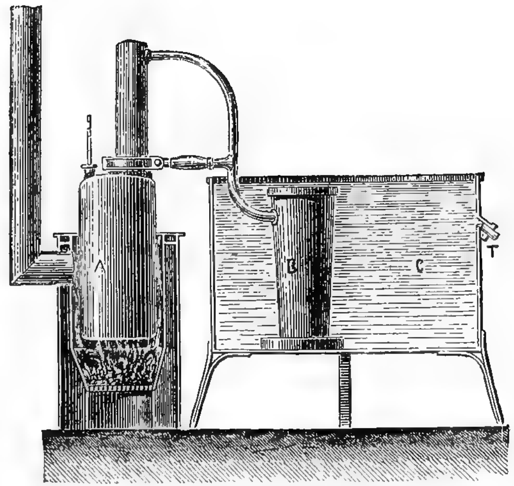

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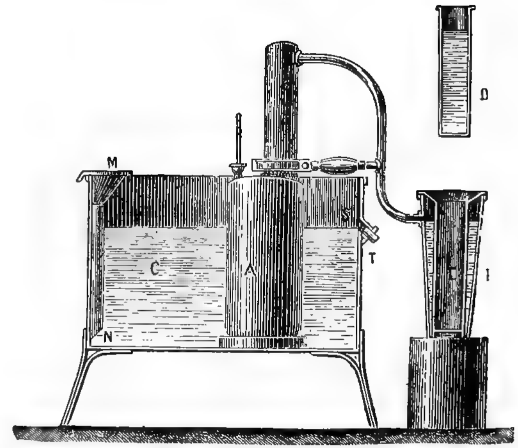

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ICE MACHINE. CARRÉ INTERMITTENT SYSTEM, EXHIBITED BY ROUART FRÈRES ET CIE PARIS.

In 1858 Ferdinand Carré, of France, proposed a new and original plan of liquefying ammonia, using the aqueous solution of this gas, 25 parts of ammonia in 75 parts of water. The process is commonly known as the "absorption system" and may be either intermittent or continuous. The ammonia solution is heated in a boiler or still until the ammonia is driven off in the form of gas mixed with about 10 parts of steam and the vapor is made to pass through the three operations above described, (1) the gas is compressed by the pressure resulting from its distillation; (2) it is cooled and liquefied in a vessel or coil of pipe surrounded by cold water, and (3) it is allowed to reëxpand to a gaseous state in a vessel or coil surrounded by the substance to be cooled.

Having accomplished its work the gas is passed to a coil of pipes called the "absorber," where it comes in direct contact with the water from which it was originally expelled by heating, this water having been cooled before passing into the absorber. The solution of gas and water is then pumped to the boiler to be again distilled and condensed as before.

Carré's intermittent ammonia apparatus was exhibited in the expositions of 1867 and 1878 and was again shown by M. Carré himself in the Exposition of 1889. It is perhaps the simplest and most economical method of making ice in limited quantities, while his continuous machine with various improvements is still very extensively employed.

Messrs. Rouart Frères et Cie and Imbert Frères exhibited an apparatus for domestic use that appears to leave little room for improvement. It is exceedingly simple and effective. It is based on the Carré intermittent system and is composed of two iron vessels connected by a vent pipe of the same material. (See Pl. LIII.)

The cylinder A contains water saturated with ammonia gas at 5° C. In operating the apparatus the vessel A is heated over a gas burner or fire, and the ammonia gas is driven out of solution, and passing into the double-walled receiver B is condensed. When most of the gas has been driven out of the water, the apparatus is reversed, the retort A being cooled in cold water while the liquid which it is desired to freeze is placed in the cylinder D (Pl. LIII, Fig. 3), placed in the interior portion, E, of the hollow cylinder. A reabsorption of the ammonia by the water takes place, and a consequent evaporation of liquefied ammonia in the receiver. This evaporation is accompanied by the absorption of heat which becomes latent in the gas. Thus the receiver is soon cooled down far below the freezing point, and the liquid contained in the vessel D is frozen.

The machine is made in several sizes. One to make 2 pounds of ice, requiring 2 hours for the operation, costs $35, complete with furnace, and a machine making 4½ pounds in 3 hours, costs $55. The time required for heating is about the same as that for freezing.

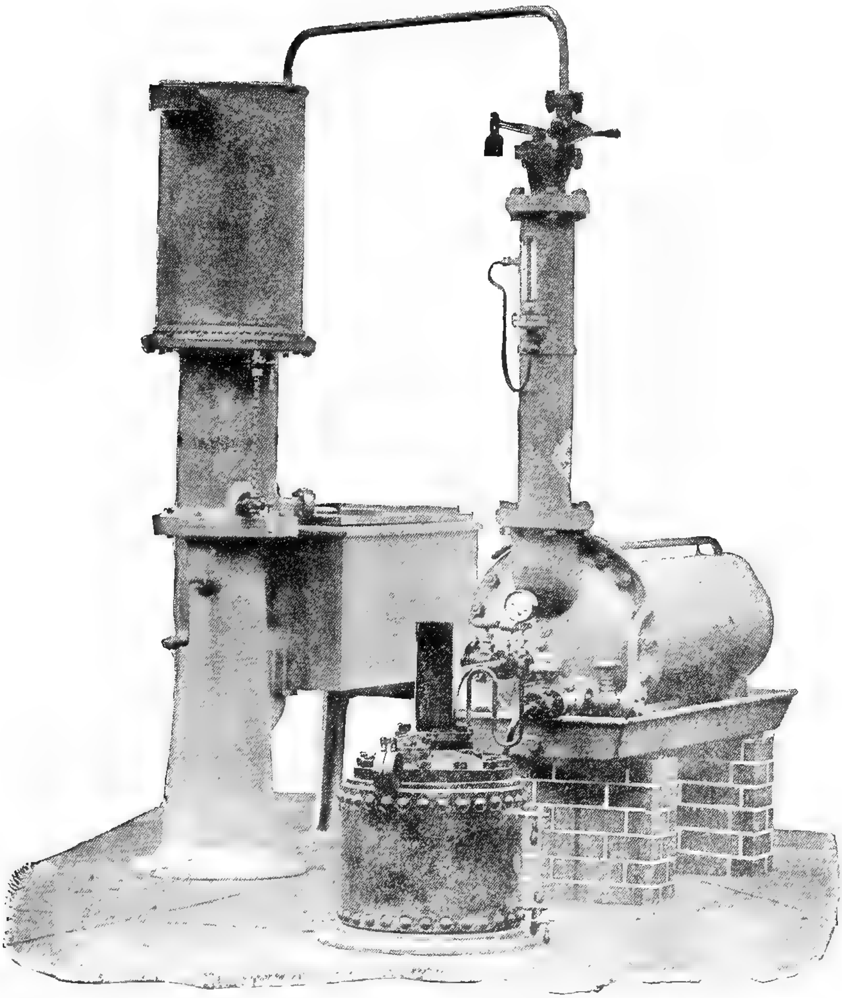
In the illustration, Fig. 1 shows the position of the apparatus when not in use. Fig. 2 shows the heating process, and Fig. 3 the freezing operation. Very many of these machines are used in France and in other countries. A machine of 550 pounds capacity, taking 4 hours to complete the freezing, costs $740 to $900. It is illustrated in Plate LIV.

The same principles involved in the intermittent apparatus, which is adapted especially for domestic use, are elaborated in the continuous apparatus. In the latter machines, that have a capacity of from 50 pounds to 4,000 pounds of ice, there are four instead of two organs or parts, as shown in Plate LV; the apparatus has a boiler or heater which contains the solution of gas and water, the gas by heat being driven over into a condenser and then into a congealer, which again separates the gas from the water in the manner already described. Messrs. Rouart Frères et Cie, 137 Boulevard Voltaire, and Imbert Frères, of St. Chamond, France, also exhibited the Carré continuous machine in operation daily, and excellent results were shown in quality of ice and economy of production. These machines cost $900 for the 50-pound size, $4,000 for 400-pound size, and so on up to $25,000 for the 2-ton size. Under favorable circumstances ice may be produced with these machines for about one-tenth of a cent per pound.

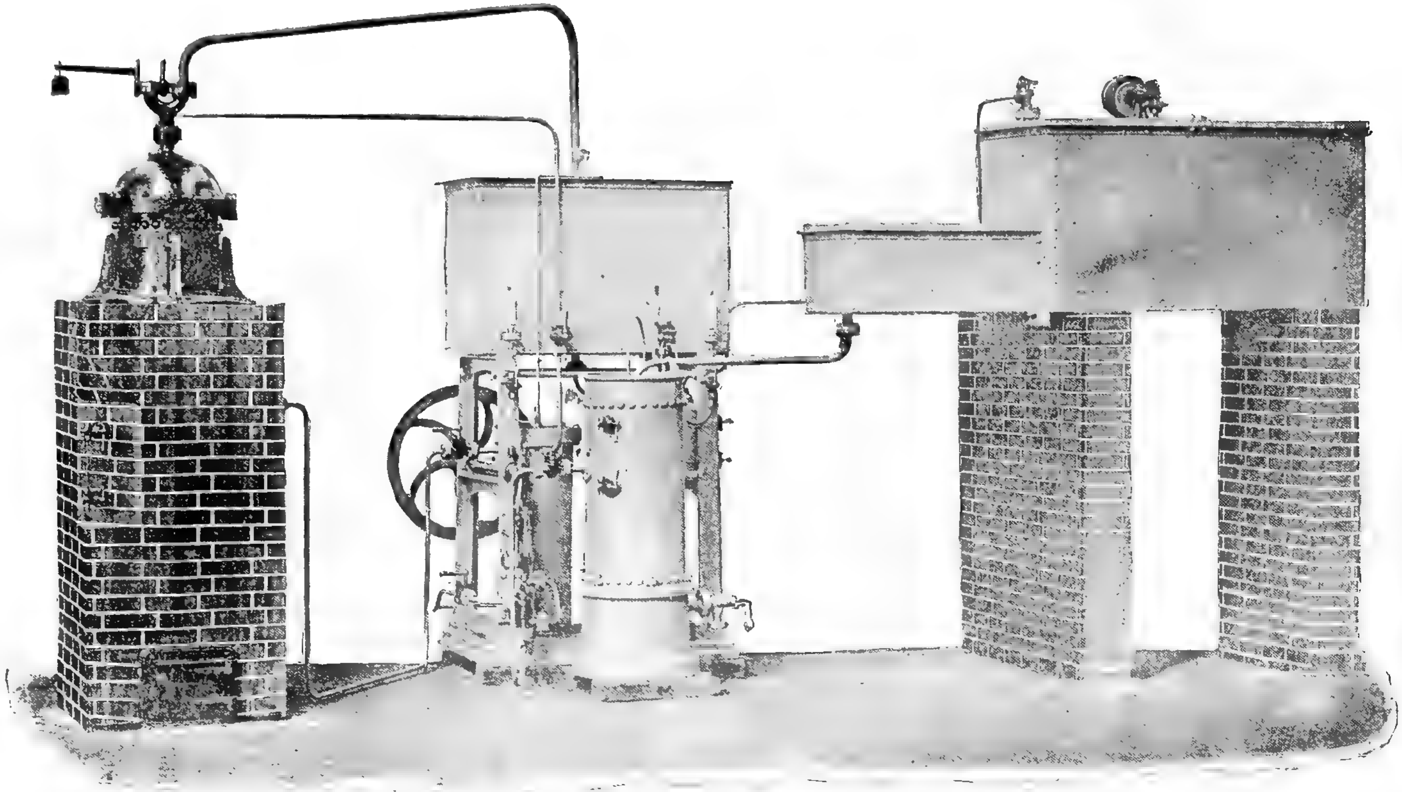
PICTET SYSTEM WITH SULPHUROUS ACID.

Some ice and refrigerating machines operated under the inventions of Raoul Pictet were exhibited by the Compagnie Industrielle des Procèdès Raoul Pictet, 19 rue de Grammont, Paris. The agent employed is anhydrous sulphurous acid (SO^2). The theory of the apparatus is based in the continuous passage of the sulphurous acid from the liquid to the gaseous state, a physical change which is the source of cold.

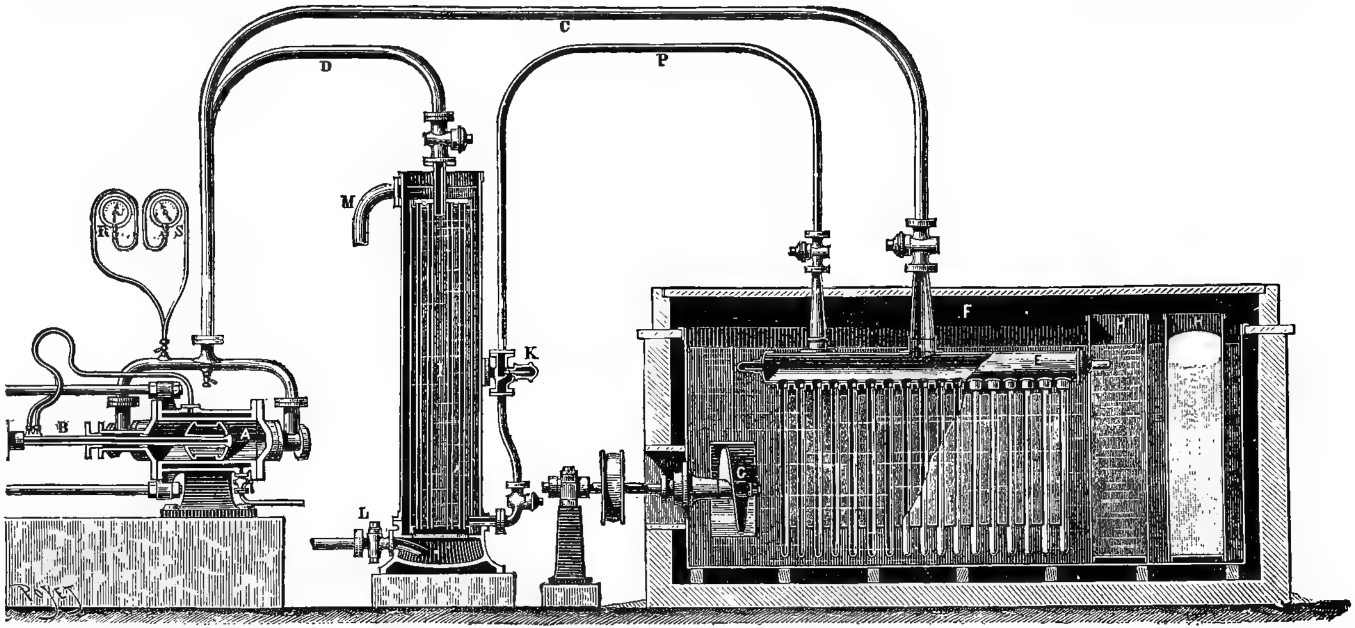
The construction of the machine is shown in Plates LVI, LVII. It has the parts essential to effect the three steps in the process common to most machines: (1) Compression; (2) condensation; (3) reëxpansion. The compression is here accomplished directly upon the gas by mechanical means instead of by the pressure resulting from the distillation of the gas, as in the Carré system. In the Plates A is the compression pump, B is the piston compressor. The compressed gas is driven through the tube D into the condenser I, where it is liquefied bythe action of cold water entering by tube L and passing out by tube M. The liquefied gas passes under pressure through tube P into the tubes E, which are surrounded by an uncongealable liquid (solution of chloride of magnesium), and absorbing the heat of the liquid cools the latter and is itself reëxpanded to



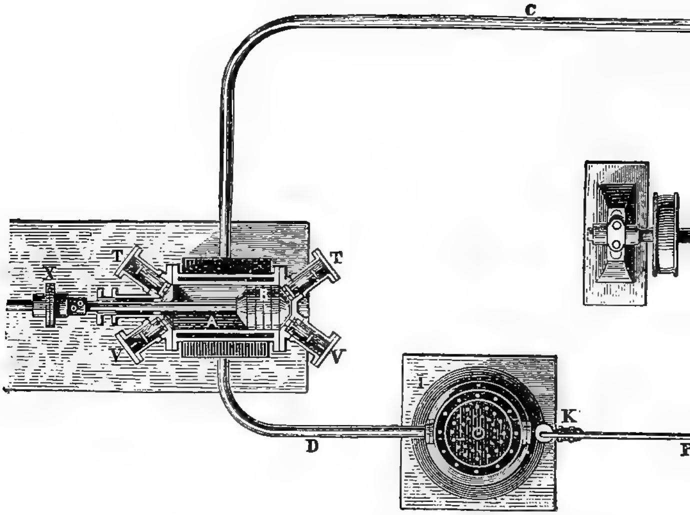
ICE MACHINE. CARRÉ SYSTEM, MADE BY ROUART FRÈRES ET CIE, PARIS.



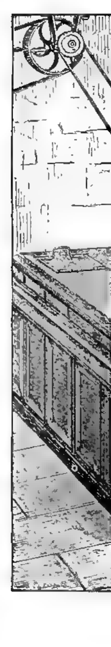
REFRIGERATING AND ICE MACHINE, CARRÉ CONTINUOUS SYSTEM, MADE BY ROUART FRÈRES ET CIE, PARIS.

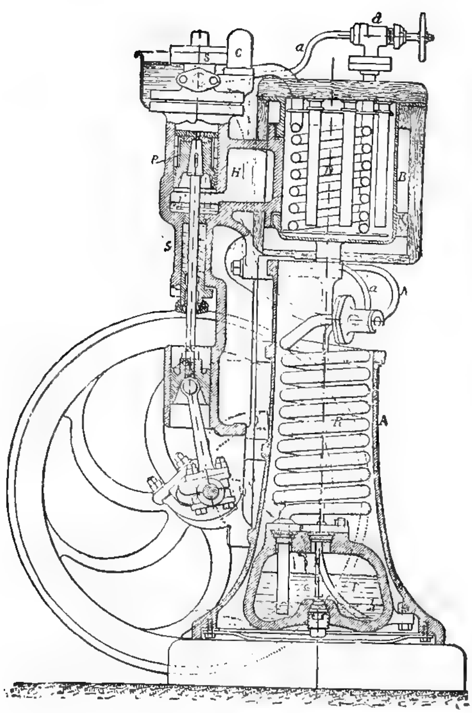


PICTET ICE MACHINE, SIDE VIEW.

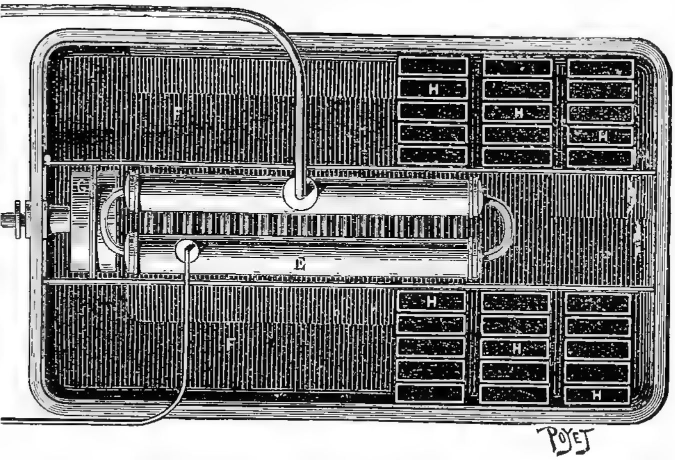


PICTET ICE M

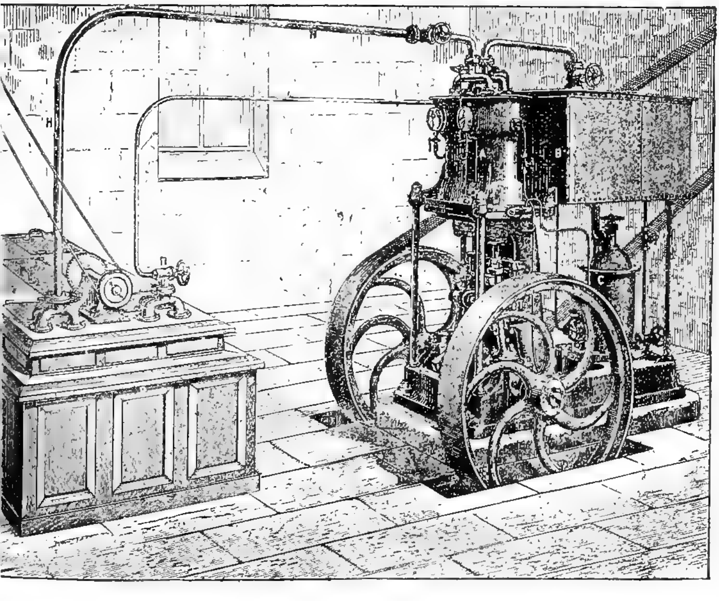




1. PORTABLE ICE MACHINE, FIXARY SYSTEM.



.CHINE, PLAN.



2. ICE MACHINE, FIXARY SYSTEM.

return as gas to the compressor. The water to be frozen is contained in tanks H H, surrounded by the cold liquid, and is soon converted into ice, its heat being taken up by the liquid; K is a regulating valve, G, an agitator to keep the liquid in motion, R and S pressure gauges.

The cost of making ice with a Pictet machine of 1 ton capacity is about $1.40 per ton, and with a machine of 500 pounds capacity it is $2.20 per ton. These figures include cost of fuel for the motor, labor, and all materials.

LINDE SYSTEM.

In the Swiss section there was an ice machine on the Linde system. Anhydrous ammonia is compressed with a pump, condensed, and re-expanded in the same essential manner as in other machines of this class. Some special features of the mechanism of the apparatus permit economy of space and of labor in operation. These machines were exhibited by Messrs. Sulzer Frères, of Winterthur, Switzerland.

FIXARY SYSTEM.

The Société des Constructions Mécaniques Spéciales, of 242 to 248 rue Lecourbe, Paris, made an excellent exhibit of ice making and refrigerating machines operated on the Fixary system. Anhydrous ammonia is the agent used, and the action of the machine is mechanical compression with a pump. One of the advantages of this machine is the alleged superior construction of the pump, which is shown in Fig. 8. There are two pistons, and under each one is a chamber of mineral oil, into which the piston partially plunges at each stroke.

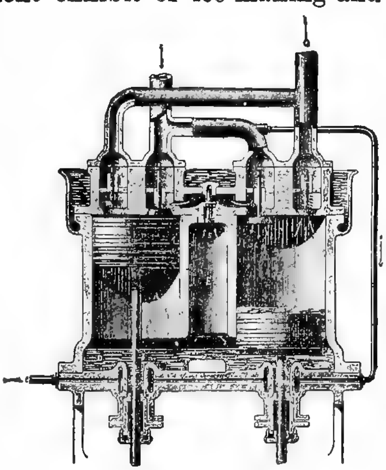


FIG. 8.—Compression pump of Fixary ice machine.

Economy in loss of the gas and in power and ease of compression are said to result from the use of this pump.

A simple type of the Fixary machine, with capacity of 10 to 20 pounds of ice per hour, is catalogued at $300 to $500, weighing 1,000 and 1,500 pounds respectively, for the two sizes (Pl. LVII, Fig. 1).

They are made of 3,000 pounds capacity. One ice factory in Paris operating the Fixary system produces 75 tons of ice per day. The arrangement of the apparatus is shown in Plate LVII, Fig. 2.

In the illustration A is the pump for compression of gas, B the condenser or liquefier, which is provided with a serpentine pipe all in one piece, and D is the congealer in which the gas reëxpands and cools the incongealable liquid which surrounds the water to be frozen.

WINDHAUSEN SYSTEM.

The Société Émile et Jules, Halot et Cie, of Brussels, made an exhibit of ice-making and refrigerating machines operated on the Windhausen system by the use of carbonic acid, for which some advantages are claimed as a cold-producing agent. It is said not to attack the metal of the machine, is not dangerous to operate, and has no unpleasant odor. The action of this machine is by mechanical compression. The cost of production of ice is about three-tenths of a cent per pound of ice.

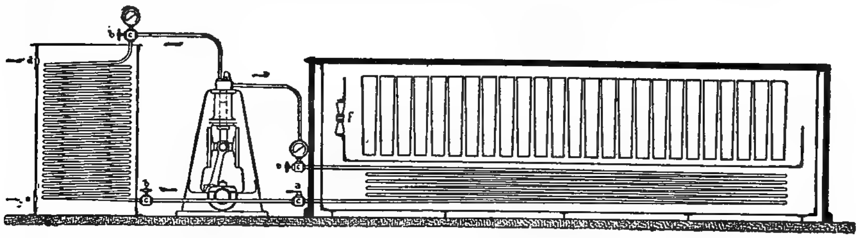


Fig. 9.—Ice machine, Windhausen carbonic acid system.

The Windhausen system was exhibited also in the Swiss section by Escher, Wyss & Co., of Zurich. Fig. 9 shows the arrangement of one of these machines of 600 pounds production of ice per hour.

Another machine to make 20 to 100 pounds of ice per hour is shown in Plate LVIII.

VINCENT SYSTEM.

A machine to make ice by the use of methyl chloride as the agent was exhibited by Doaune, Jobin & Co., 23 Avenue Parmentier, Paris. The construction of this machine (Pl. LVIII, fig. 2) consists of a compression pump, a liquefier, and a freezer, in which the gas reëxpands to be drawn back again to the pump.

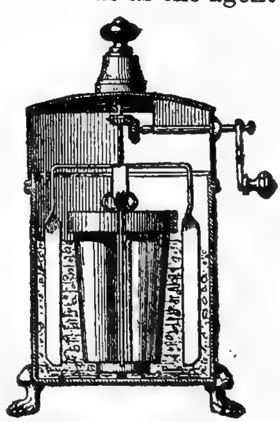
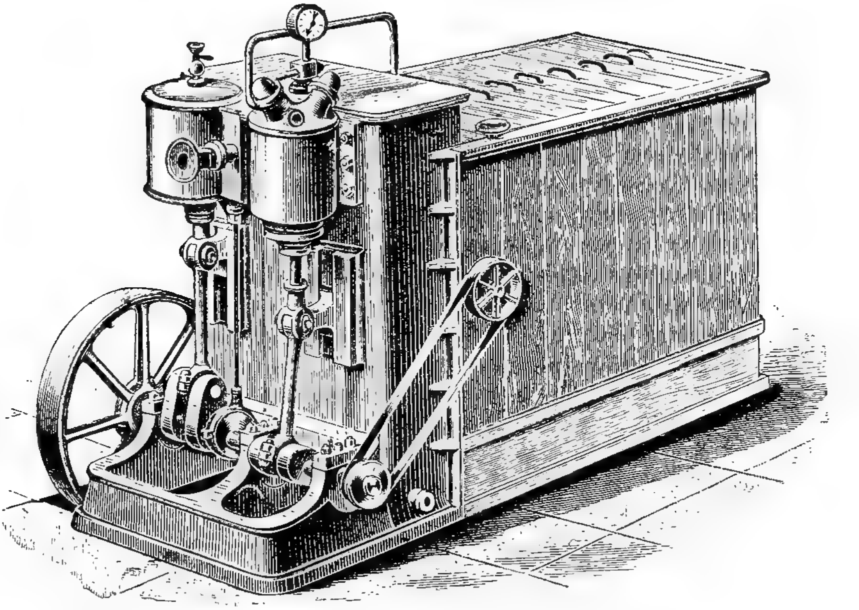
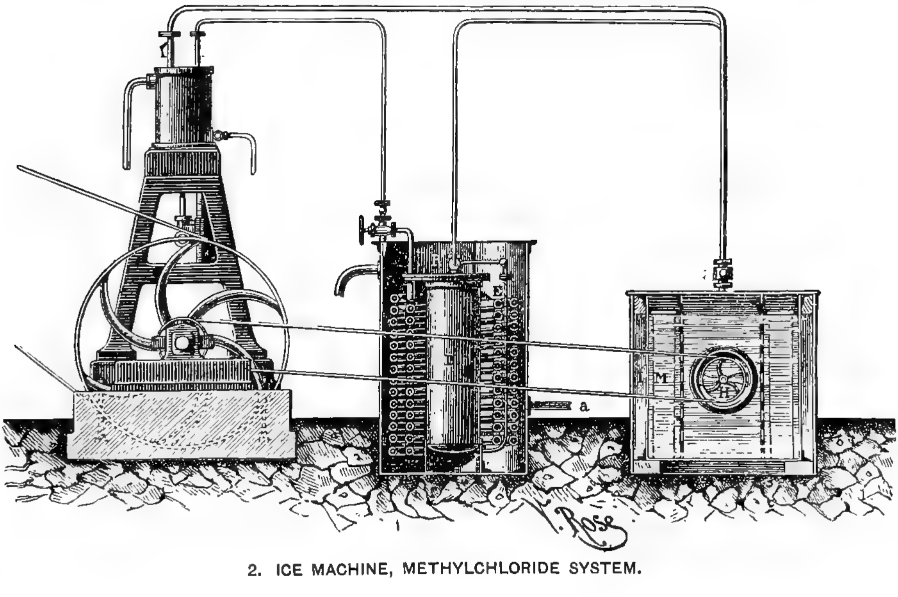


Fig. 10.—Household ice machine.

Numerous ice machines of small size for household use were exhibited. These are made on the general principle of ice-cream freezers. The freezing mixtures used are various, as indicated on a preceding page. A quick-working machine to produce a block of ice in a few minutes was exhibited by L. Delpy, 27 rue Bleue, Paris. They vary in size to produce from one-half pound to eight pounds of ice. The mixture used is sulphate of soda and muriatic acid.



1. ICE MACHINE, WINDHAUSEN CARBONIC ACID SYSTEM.



2. ICE MACHINE, METHYLCHLORIDE SYSTEM.

CLASS 72.—SUGAR, COFFEE, TEA, COCOA, SPICES AND CONDIMENTS; LIQUEURS, PRESERVES,

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CLASS 72—SUGAR, COFFEE, TEA, COCOA, SPICES AND CONDIMENTS, LIQUEURS.

This class includes an almost infinite variety of food products from all parts of the world. The exhibits were very complete indeed. I shall attempt to discuss only the more important commercial articles, as sugar, coffee, tea, cocoa, and chocolate, and some spices.

I.—THE AWARDS.

The jury in their examination of objects made three subclasses: (1) coffees and teas; (2) chocolate, sugar, and preserves, and (3) liqueurs.

The number of awards given to the several countries is shown in the following tables:

SECTION I.—*Coffee and tea.*

	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
Guatemala	2	17	91	39		149
Brazil	2	19	39	28	6	94
Nicaragua	1	7	52	31		91
Réunion	1	38	44	4	1	88
Portugal	1	12	21	17	5	56
Venezuela	2	13	24	15		54
Dutch East Indies	2	9	15	11	2	39
San Salvador	1	12	22	1		36
New Caledonia		12	20			32
Mexico		7	16	8		31
Spain		6	7	1	1	15
France			3	3	7	13
Guadeloupe		7	5		1	13
Dominican Republic	1	1	2	4	1	9
Ecuador	1	3	5			9
Argentine Republic			1	1	5	7
Japan		1	4	2		7
Haiti		1	3			4
Tahiti		1	3			4
Paraguay	1			2		3
Martinique		1	2			3
Senegal		1	2			3
Cochin China		2	1			3
Great Britain		1	2			3
Bolivia			3			3

SECTION I.—*Coffee and tea*—Continued.

	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
Gabon Congo			3			3
Chile			1		1	2
French India			1		1	2
Algeria				1	1	2
Peru				1	1	2
Mayotte and Comoros				1	1	2
China	1			1		2
Costa Rica	1					1
Italy					1	1
Cambodge					1	1
Honduras		1				1
Colombia		1				1
Madagascar		1				1
South African Republic			1			1
Assinie			1			1
Russia				1		1
Hawaiian Islands			1			1
Total	17	175	396	171	35	794

SECTION II.—*Sugar, chocolate, and confectionery.*

	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
France	2	21	35	50	14	122
Mexico	1	1	6	13	21	42
Brazil	3	7	7	17	7	41
Spain		7	6	12	15	40
Argentine Republic		1	2	8	10	21
Japan			1	14	6	21
Russia	1	10	3	4	1	19
Netherlands		2	4	5	6	17
Guatemala		1	1	1	14	17
Algeria			6	2	8	16
United States of America		1		5	8	14
Portugal				9	5	14
Réunion Island		2	3	6	2	13
Guadeloupe		2	5	1	3	11
San Salvador				3	7	10
Belgium		3	2	3	1	9
Dominican Republic			1	2	6	9
Great Britain		2	3	2		7
Italy			2	2	3	7
Chile				2	4	6
Martinique		1	3		2	6
Switzerland		2	2		2	6
Cochin China				4		4
Venezuela				2	1	3
San Marino				1	2	3
Finland			1		2	3
Ecuador		1	1	1		3
Roumania		1			2	3
Servia				1	2	3
Mayotte and Comores				2		2

SECTION II.—*Sugar, chocolate, and confectionery*—Continued.

	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
French India			1		1	2
Egypt			1		1	2
Monaco			1	1		2
Greece				1	1	2
Portuguese Colonies				1	1	2
Tunis					2	2
Nicaragua					1	1
Tahiti				1		1
Persia					1	1
Norway				1		1
Paraguay					1	1
Uruguay				1		1
Bolivia					1	1
South African Republic				1		1
Hawaiian Islands				1		1
Luxembourg				1		1
New Caledonia				1		1
Total	7	65	97	182	164	515

SECTION III.—*Liquers.*

	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
France	1	41	70	115	56	293
Algeria		2	10	29	18	59
Spain		3	14	29	12	58
Mexico		1	7	12	9	29
Switzerland			7	11	6	24
Argentine Republic		2	4	4	12	22
Brazil		1	5	4	7	17
Russia		3	5	5	2	15
Italy		2	5	4	4	15
Martinique		1	4	5	3	13
Belgium		2	1	8		11
Netherlands		2	7	1		10
Portugal		1		5	3	10
Greece		1	3	5	1	10
Tunis		1	1	5	2	9
Venezuela			2	2	4	8
Guadeloupe			2	2	3	7
Uruguay		1	1	2	2	6
Réunion		2	2		1	5
Roumania			1	2	2	5
Norway		1	3			4
Paraguay		1	1		1	3
Dominican Republic					3	3
San Salvador			2		1	3
Finland		1	1			2
Monaco		1		1		2
Senegal		1	1			2
Sweden			1	1		2
Denmark			1		1	2
San Marino			1	1		2

SECTION III.—*Liquers*—Continued.

	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.	Total.
French Guiana			1		1	2
Guatemala				1	1	2
French India			1			1
United States			1			1
Austria			1			1
South African Republic			1			1
Great Britain			1			1
Tonkin				1		1
New Caledonia				1		1
Total	1	68	168	252	156	645

II,—EXHIBITS BY THE UNITED STATES.

The exhibits by the United States in this class are enumerated in the list below. It is much to be regretted that our display was so very meager. Only one gold, one silver, and five bronze medals, with eight honorable mentions were awarded the United States, and it was chiefly owing to the good reputation of the firm, rather than the excellence of the articles shown, that the single gold medal was given. And this, too, in a class where the manufactures of our country have taken a high rank.

Mrs. C. A. Bacon, Ormond, Florida, guava jelly and preserves.

Collective exhibit prepared under the direction of the Secretary of Agriculture, Washington. D. C. Sorghum sirup, sorghum heads of different varieties showing development of the plant. Sorghum sugar refined, etc.

Conway Springs Company, Conway Springs, Kansas. Sorghum sugar refined.

Douglas Sugar Company, Douglas, Kansas. Sorghum sirup. Sorghum sugar refined.

Alice K. Fawcett, Ormond, Florida. Guava jelly.

S. H. Kinney, Morristown, Minnesota. Sorghum sirup. Sorghum heads of the "early amber" variety cultivated at the 43° of latitude. Sorghum sugar refined.

James Lutted, New York City. Specimens of candies and confectionery made by hand and steam power.

Henry W. Maillard, New York City. About 3,000 different styles of bonbons and fancy chocolate. Two chocolate vases, height, 1.45 meters, weight, 450 kilogrammes. Full size reproduction in chocolate of the statue "Venus de Milo."

George Miller & Son, Philadelphia, Pennsylvania. Confectionery; American candies.

Palisade Manufacturing Company, West Hoboken, New Jersey. Tournade's kitchen bouquet, concentrated essence for flavoring soups, gravies, etc.

Mary E. Ross, New York City. Excelsior sauce.

The Preserve Company, San Augustine, Florida. Preserved guava, guava jelly, marmalade, and preserved figs.

H. O. Wilbur & Son, Philadelphia, Pennsylvania. Cocoa and chocolates.

III.—THE SUGAR INDUSTRY.

COMMERCIAL IMPORTANCE OF SUGAR.

The term "sugar" formerly signified anything having a sweet taste, but it is now limited to certain organic compounds belonging to two chemical genera called respectively *saccharoses* and *glucoses*, the former having the composition represented by the formula $C_{12}H_{22}O_{11}$, the latter by the formula $C_6H_{12}O_6$. Both classes are colorless, nonvolatile solids, soluble in water and less freely in aqueous alcohol; have a more or less sweet taste, and, whether solid or in solution, have the power of rotating the plane of polarization of light.

The principle saccharoses are: (1) Cane sugar, found in the sugar cane, beet, sorghum, maple, palm, and many other plants. (2.) Milk sugar or lactose, occurring in the milk of mammals. (3) Malt sugar or maltose, produced when starch is acted upon by very dilute acids, or by the ferment called "diastase."

The glucoses include a considerable number of substances from various sources, the most important being: (1) Grape sugar or dextrose, found in the juices of sweet fruits, in the human liver, and as a product of the decomposition of the vegetable principle known as *glucosides*, or of the conversion of cane sugar; it is also produced industrially from starch. (2) Fruit sugar or levulose, fonnd in honey, and associated with grape sugar in certain fruits. (3) Muscle sugar or inosit, present in the juice of some meats, and in asparagus and other plants.

"Invert sugar" is a mixture of dextrose and levulose, and is a product of the conversion of cane sugar by the action of ferments or of weak acids. Like levulose, and unlike the other sugars mentioned above, invert sugar deviates the plane of polarized light to the left.

The following are the principal varieties of sugar of commercial importance:

(1) Cane sugar, from the stem of *Saccharum officinarum.*

(2) Beet sugar, from the roots of *Beta maribtrima.*

(3) Sorghum sugar, from the stem of *Sorghum saccharatum.*

(4) Maple sugar, from the sap of *Acer saccharinum* and other species of *Acer.*

(5) Palm sugar ("jaggery"), from the sap of *Phœnix sylvestris* and other palms.

(6) Starch sugar ("glucose"), prepared chemically from potato or corn starch.

(7) Milk sugar, from the whey of cow's milk.

The sugar industry in all its phases was fully represented at the Exposition. Most of the great sugar-producing countries of the world, with the exception of Germany, had samples of the raw and refined sugar and other products made from the cane, the beet, and

from other less important sources. The consumption of sugar in the world (exclusive of the great local consumption in India and China) is now nearly 5,200,000 tons a year, which is more than double the consumption twenty-five years ago, and from present indications it may again double within the next quarter of a century.

The sugar beet and the sugar cane are the two great sources of supply. Sorghum sugar and sirup, maple sugar and sirup, palm sugar, and some other varieties, are local commodities of greater or less importance, but, with the exception of palm sugar, they do not at present affect the markets of the world.

The culture of sugar cane is carried on in warm countries and that of the sugar beet in certain temperate regions, chiefly of Europe. The extraction of sugar from cane and from beets has given birth to two great rival industries, which are now of nearly equal importance.

The average annual production of cane sugar is 2,600,000 tons, and of beet sugar 2,400,000 tons. The statistics of production since 1884 are as follows:

The total sugar production of the world, 1884 *to* 1889.

Season.	Beet sugar.	Cane sugar.	Total.
	Tons.	*Tons.*	*Tons.*
1884–'85	2,545,899	2,592,647	5,138,536
1885–'86	2,157,351	2,702,850	4,840,201
1886–'87	2,658,700	2,608,000	5,266,700
1887–'88	2,386,729	2,806,000	5,192,729
1888–'89	2,635,000	2,597,000	5,232,000
Average	2,472,734	2,661,299	5,134,033

The United States consumes 29 per cent and the United Kingdom 21 per cent of the total sugar production of the world. The proportion used in the several countries is as follows:

	Tons.	Pounds per capita.
United States	1,500,000	52
United Kingdom	1,100,000	72
France	450,000	24
Germany	330,000	22
Russia (including Poland)	450,000	9
Austria-Hungary	280,000	13
Holland	60,000	
Belgium	40,000	
Sweden and Norway	50,000	
Spain, Portugal, and Italy	170,000	
Other countries of Europe	70,000	
Australia	120,000	
Other countries	580,000	
Total	5,200,000	

The importation of cane and beet sugar into the United Kingdom in 1887 aggregated 2,800,747,936 pounds, and the importation into the United States in 1888 was 2,638,298,405 pounds. Canada buys annually 150,000,000 to 200,000,000 pounds of sugar, mostly from the West Indies and South America.

The details of imports into the United Kingdom and into the United States are given in the following tables:

Statistics of importation of sugar into the United Kingdom during the year ended December 31, 1887.

Country.	Crude cane sugar.	Refined cane sugar.	Crnde beet sugar.	Refined beet sugar.	Total.
	Cwt.	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
English West Indies, including Guiana and Honduras	2,147,060				2,147,060
British India, Ceylon	828,547				828,547
Maurice	104,986				104,986
Other English Possessions	99,890				99,890
Brazil	869,843				869,843
Central and South America except Brazil	587,481				587,481
West Indies, not English	185,587				185,587
East Indies, not English	3,660,729				3,660,729
Other countries	302,387	3,622			306,009
France			61,186	1,548,718	1,616,904
Germany			7,658,481	2,832,815	10,491,296
Belgium			1,063,014	216,717	1,279,731
Netherlands			407,008	1,501,197	1,908,205
United States		775,833			775,833
Denmark			26,506		26,509
Russia			658	117,390	118,048
Total	8,786,510	779,475	9,223,856	6,216,837	25,006,678

Statistics of importation of sugar into the United States during the year ended June 30, 1888.

Country.	Beet sugar.		Cane sugar.	
	Pounds.	Value.	Pounds.	Value.
Austria-Hungary	110,250	$2,370		
Belgium	7,125,870	190,177		
Brazil			305,866,337	$6,752.555
Gautemala			4,620,225	176,906
San Salvador			3,076,850	85,607
China			691,735	16,911
Danish West Indies			11,103,826	295,312
France	7,095	336		
French West Indies			5,706.337	109,859
Germany	51,533,917	1,322,516		
England	2,951,475	74,876	806,880	26,810
Canada			239,036	21,112
British West Indies			302,596,709	6,936,995
British Guiana			94.914,020	2,813,992
British Honduras			928,873	23.761

Statistics of importation of sugar into the United States, etc.—Continued.

Country.	Beet sugar.		Cane sugar.	
	Pounds.	Value.	Pounds.	Value.
British East Indies			10,573,089	$153,241
Hongkong			484,665	10,400
British Possessions in Africa			8,788,860	155,555
Hawaiian Islands			228,540,513	10,260,048
Haiti			534,220	15,104
Mexico			614,574	14,543
Netherlands	221,145	$4,501		
Dutch Guiana			2,194,889	62,771
Dutch East Indies			6,254,411	124,142
Azores, Madeira, and Cape Verde			1,236,267	36,560
San Domingo			44,793,992	1,248,544
Cuba			1,209,170,332	34,545.116
Porto Rico			115,653,809	2,997,713
Philippine Islands			274,809,392	5,641.998
United States of Colombia			4,094,845	123,047
Venezuela			3,719	186
Total	61,949,752	1,594,776	2,638,298,405	72,648,788

Quantity of sugar produced in Louisiana, imported into and exported from the United States, with the annual average specific rates of duty and amounts of duty collected on, and cost per pound of, imported sugar, for each year from 1851 *to* 1887, *inclusive.*

[Prepared by U. S. Bureau of Statistics.]

Year ending June 30—	Production in Louisiana.	Imports of sugar.				Exports of domestic and foreign sugar. *
		Quantity.	Average specific rate of duty.	Duty collected.	Average cost per pound in foreign country.	
	Pounds.	*Pounds.*	*Cents.*	*Dollars.*	*Cents.*	*Pounds.*
1851	231,194,000	380,402,289	1.08	4,043,612.70	3.60	9,638,477
1852	257,138,000	457,511,093	.93	4,175,758.80	3.11	12,071,747
1853	368,129,000	464,402,286	.99	4,250,501.10	3.18	24,809,032
1854	495,156,000	455,928,585	.86	3,481,423.80	2.89	61,897,740
1855	385,227,000	473,809,847	.90	3,981,921.90	3.02	44,876,018
1856	254,569,000	545,226,430	1.22	6,385,974.90	4.08	32,612,090
1857	81,373,000	776,984,262	1.64	12,477,020.10	5.45	20,070.048
1858	307,666,700	519,200,387	1.02	4,550,639.28	4.26	82,107,244
1859	414,796,000	655,846,362	1.09	6,797,879.28	4.55	40,166,325
1860	255,115,750	694,838,197	1.05	6,941,553.12	4.38	38,476,823
1861	265,063,000	809.749,958	.75	6,511,251.19	3.68	86,913,641
1862	528,321,500	557,738.382	1.76	11,624,493.64	3.66	26,307,117
1863	(†)	518,594,861	2.53	11,118,544.38	3.63	19,748,856
1864	84,500,000	682,230,247	2.54	14,301,234.65	4.68	29,343,689
1865	10,800,000	651,936,494	3.05	17,642,958,88	4.39	32,635,280
1866	19,900,000	1,000,055,024	3.08	27,312,967.65	4.02	13.027,910
1867	42,900,000	849,054,006	3.04	28,570,492.23	4.09	20,340,676
1868	41,400,000	1,121,189,415	3.04	30,447,970.89	4.33	18,329,940
1869	95,051,225	1,247,833,430	3.04	30,923,907.06	4.74	20,995,911
1870	99,452,940	1,196,773,569	3.03	36,819,041.26	4.95	22,760,904

* Consist almost entirely of sugar refined from imported sugar.

† No data.

Quantity of sugar produced in Louisiana, etc.—Continued.

Year ending June 30—	Production in Louisiana.	Imports of sugar.				Exports of domestic and foreign sugar.*
		Quantity.	Average specific rate of duty.	Duty collected.	Average cost per pound in foreign country.	
	Pounds.	*Pounds.*	*Cents.*	*Dollars.*	*Cents.*	*Pounds.*
1871	168,878,592	1,277,473,653	2.50	30,751 497.34	4.94	14,203,714
1872	146,906,125	1,509,185,674	2.04	28,865,447.02	5.37	16,598,822
1873	125,346,493	1,568,304,592	2.01	29,832,579.43	5.35	34,010,402
1874	103,241,119	1,701,297,869	1.98	32,491,318.70	4.95	29,442,750
1875	134,504,691	1,797,509,990	2.10	34,650,084.66	4.35	35,350,785
1876	163,418,070	1,493,977,472	2.38	39,438,417.55	4.04	67,730,198
1877	190,672,570	1,654,556,831	2.34	35,268,294.48	4.91	42,872,675
1878	147,101,941	1,537,451,934	2.33	37,075,426.96	5.06	50,109,065
1879	239,478,753	1,834,365,836	2.32	38,065,803.76	4.10	82,741,564
1880	198,962,278	1,829,291,684	2.44	39,739,306.49	4,18	40,640,206
1881	272,982,899	1,946,745,205	2.45	46,318,073.49	4.41	31,980,791
1882	159,874,950	1,990,152,374	2.44	46,711,795.14	4.41	19,436,376
1883	303,066,258	2,137,667,865	2.31	44,591,448.98	4.37	30,550,506
1884	287,712,230	2,756,416,896	1.95	47,500,749.79	3.61	85,532,916
1885	211,402,963	2,717,884,653	1.97	50,885,915.89	2.67	258,163,890
1886	286,626,486	2,689,881,765	2.00	50,265,538.24	2.84	175,836,220
1887	181,123,872	3,136,443,240	1.80	56,507,495.57	2.50	204,241,167

Consist almost entirely of sugar refined from imported sugar.

Palm sugar, called also date sugar, is the product of the juices of many kinds of palms, the most important being the wild date palm. The palmyra palm, cocoanut palm, the gemutis, and some other species also yield sugar. They are natives of India, Ceylon, Siam, and the Malay Peninsula. Some samples of good quality of palm sugar were exhibited by several of the Oriental countries, and also by Algeria. This sugar is generally made in a very crude manner, and in consequence it is too impure and unsightly for consumption in raw condition. It is, however, imported in large quantities and refined. It is estimated that in some years one-fifth of the sugar exported from India to England is palm sugar.

Starch sugar is prepared chemically from potato or corn starch. The starch is heated with dilute sulphuric acid, being changed first into soluble starch and then into dextrin and starch sugar. It can be made directly from potatoes, grain, moss, wood, fruit, honey, etc. In the United States corn starch is chiefly employed, and in Europe potato starch.

It is found in commerce as starch sirup, glucose (a heavy sirup), granulated sugar, common solid sugar, and refined solid starch sugar. As it has no application not met by cane or beet sugar or molasses, it is merely used as a substitute for those articles, and its manufacture is advantageous only when it can be produced at a less price than the standard sugars and molasses.

In the United States the annual production of "glucose," which is the popular term for starch sugar whether in sirup or solid form, is about 450,000,000 pounds.

The operations in the manufacture of corn-starch sugar are (1) Boiling the starch in sulphuric acid water; (2) removal of the sulphuric acid, in the state of sulphate of lime, from the solution; (3) evaporating and refining the sugar solution. As no apparatus employed in this industry was shown at the Paris Exposition, I shall not discuss the subject in this report.

The preparation of sugar from sorghum has been practiced on a limited scale for very many years, but it is only within twenty years that much effort has been made to develop an important industry. The processes employed are much the same as in the sugar-cane industry. The product is a juice, as a rule poor in crystallizable sugar, and consequently of low commercial value as sugar, though largely employed as a sirup in several parts of the world. The application of the process of diffusion gives much better results than the old methods, especially in the United States, our government having made extensive experiments with the prospect of developing a prosperous industry.

Sorghum sugar and sirups were exhibited from Algeria. In Italy considerable study has been given to these products.

"Barley sugar," so called, is pure sugar melted by heat and allowed to solidify *en masse* instead of crystallizing.

"Sugar candy" is a solution of sugar crystallized by slow evaporation in very large crystals, centered around threads suspended in the liquid for the purpose of forming the nuclei. Some very handsome sugar candy was shown by the French manufacturers. One of its principal uses is in the preparation of champagne.

Molasses, properly speaking, is the dark, impure liquid separated in the process of making and refining cane or beet sugar. It consists of a mixture of crystallizable and uncrystallizable sugar, colored by caramel. By the improved process of sugar-making, the proportion of molasses is very much less than formerly.

"Sirup" is the molasses obtained by washing and machining the better grades of refined sugar.

REVIEW OF SUGAR INDUSTRY BY COUNTRIES.

THE UNITED STATES

The United States, had exhibits of maple-sugar and sirups, sorghum sugar and sirups, also sugar and molasses from sugar cane. It is unfortunate that circumstances prevented the exhibit of samples of beet sugar, for Europeans would have been pleased to see the excellent results obtained in our country from this industry, now in its infancy.

Cane sugar.—The cultivation of cane sugar is carried on chiefly in the state of Louisiana, although there are also plantations in Texas and in Florida. The average annual production of cane sugar is about 300,000,000 pounds, more than 90 per cent of which is produced in Louisiana. Improvements in methods of manipulating the juice have greatly increased the relative quantity of sugar obtained from the cane. By the old method of milling the sugar averaged only about 50 pounds to a ton of cane, but by the new process of diffusion the result is 120 pounds to the ton. The proportion of sugar in cane juice is from 10 to 15 per cent, or an average of 13 per cent.

Beet sugar.—There are many portions of the United States suited to the culture of the sugar beet, especially in California, Nebraska, Iowa, Wisconsin, Michigan, Indiana, Ohio, northern New York, and also in the New England States.

California is the only state thus far equipped with machinery for carrying on the manufacture of beet sugar, and it is from that State and Nebraska that the best results may be expected. The latter state has produced beets equal in sweetness to the best of German or French growth. Apparently, all that is needed to make this a gigantic industry in the United States is enterprise and capital. The total production of beet sugar in the United States in 1888 was about 40,000,000 pounds, valued at $200,000.

Sorghum sugar.—Sorghum sugar has become an important commercial article. The product in 1888 was more than 6,500,000 pounds, made in Kansas, which State is the center of the industry. The sirup of sorghum, however, is largely used instead of cane molasses for domestic purposes. The product of this sirup in 1888 was 31,000,000 gallons.

Maple sugar and sirup.—The preparation of sirup and of sugar from the sap of the sugar-maple tree is an industry carried on chiefly in Northern New England, although quantities are also made in New York, Ohio, and Indiana. The present annual production is 35,000,000 pounds of sugar, worth $3,600,000, and 2,000,000 gallons of sirup, worth $1,400,000. A small lot of samples of sugar and sirup were exhibited, but they attracted little attention.

Insufficiency of home production.—The home production of sugar goes but little way towards supplying the enormous demand of the inhabitants of our country. As shown by a table on a preceding page, the importation has been steadily increasing. In 1886 the importation was 3,136,443,240 pounds, while the home production was only about one tenth as great. The duty collected on imported sugar in 1887 was $56,507,495. The countries from which we imported this supply are given on a preceding page. It will be seen that Germany has for a number of years been steadily increasing her sendings of beet sugar to this country, and such increase will doubtless continue until the home industry is highly developed.

CUBA.

There was an interesting exhibit of commercial grades of sugar from Cuba, including products of milling and of the diffusion process which is now being introduced into that island. Cuba produces annually 700,000 tons of sugar, one fourth of the cane sugar consumed in Europe and America.

One of the largest sugar-making establishments in the world is in the district of Cienfugos, known as the "Constancia" works. It is fitted with milling machines, and also with apparatus for extraction by the diffusion process. The roller mills have a capacity of 800 tons of cane per day.

MARTINIQUE AND GAUDELOUPE.

The French colonies of Martinique and Gaudeloupe had exhibits of raw and crystalized sugars and sugared fruits. In Martinique the manufacture of rum from refuse cane molasses has attained considerable importance. "Year after year the reputation of the liquor in question has grown, and in consequence the British colonies of the vicinity have been furnishing enough of the raw material to supply the deficiency."

The sugar cane is the most important food plant cultivated at Gaudeloupe. The industry employed in 1887 nearly 41,000 workmen, and the products were 58,075,427 kilograms of sugar; 5,316,085 kilograms of sirups and molasses, and 2,890,341 kilograms of tafia.

CENTRAL AMERICAN STATES.

Gautemala, San Salvador, and other Central American States had exhibits of cane sugar. The aggregate annual production is not more than 35,000,000 pounds.

UNITED STATES OF BRAZIL.

Before the coffee industry became so important sugar cane had for a long time been the principal source of wealth of Brazil. At the end of the eighteenth century this great Portuguese colony produced annually 41,500,000 pounds of sugar. The sugar cane is now the most important culture in the province of Pernambuco, and is grown more or less extensively in other parts of the United States of Brazil. In recent years improved French machinery has been imported, and many of the sugar factories are now well equipped. The sugar industry was for some years declining in importance. Some of the reasons assigned for the depression were (1) imperfect culture, with consequent increase in cost of raw material; (2) imperfections of the agricultural experiment stations; (3) carelessness in manipula-

tion of the juice; (4) limited home consumption; (5) duty on exportation and interprovinc'al taxes.

The employment of free labor in place of slaves was a fortunate step toward renewed prosperity. It is estimated that 400,000 workers are now engaged in the sugar industry. The exportation of sugar from the province of Pernambuco (the headquarters of the industry) during the years 1882 to 1886 was as follows:

Year.	Kilograms.	Value.
1882	134,916,000	$14,080,000
1883	132,400,000	13,760,000
1884	137,893,000	10,740,000
1885	118,959,000	8,890,000
1886	106,797,000	9,010,000

A great part of the unrefined sugar is exported to the United States. The total production of Brazil in 1886 was 249,821,000 kilograms. The production for other years is shown on a preceding page.

THE ARGENTINE REPUBLIC.

The Argentine Republic had several exhibits of sugar and other products of the sugar cane. The annual yield of sugar is not sufficient for the home consumption. Of refined sugar 22,912,687 kilograms were imported in 1887, as follows: From France, 9,971,910 kilograms; from Belgium, 6,054,819 kilograms; Germany, 2,542,532 kilograms; Netherlands, 1,355,052 kilograms; England, 343,756 kilograms; Spain, 166,050 kilograms; the United States, 131,383 kilograms, and from Italy 56,087 kilograms.

PERU.

A few samples of cane sugar were exhibited from Peru. That country has large areas of soil suitable for cane culture, although the expense of the necessary irrigation has hindered a very great development of this industry.

The annual production is about 75,000,000 pounds of sugar. There, as in other sugar-producing countries, the lastest improvements in machinery are being adopted.

PARAGUAY.

Two grades of cane sugar of very good quality were exhibited by Paraguay. The cane grows well in this country and is very rich in sugar, but the industry is not enough developed to produce sufficient even for home consumption. From the juice they prepare white rum and arrack.

ECUADOR AND CHILE.

There were three exhibits of cane sugar from Ecuador and one from Chile. The sugar industry in these countries is attracting considerable attention, and will doubtless be much developed in a few years.

HAWAIIAN ISLANDS.

The sugar industry at the Hawaiian Islands has been very greatly developed during the last ten years, chiefly because of the favorable commercial relations that have existed since 1875 between the Islands and the United States, whereby the principal products of the Islands are admitted into our country free of duty. The exportations of sugar and molasses since 1876 have been as follows, almost the entire quantity being sent to the United States :

Statistics of exportation of sugar and molasses from the Hawaiian Islands, 1876 *to* 1888.

Year.	Sugar.	Molasses.	Year.	Sugar.	Molasses.
	Pounds.	*Gallons.*		*Pounds.*	*Gallons.*
1876	26,073,429	130,073	1883	114,107,156	194,997
1877	25,575,965	151,426	1884	141,654,923	110,530
1878	38,431,458	93,136	1885	171,350,314	57,931
1879	59,020,972	87,475	1886	216,223,615	113,147
1880	63,584.871	192,355	1887	212,731,647	71,222
1881	93,789,483	263,587	1888	235,888,346	47,965
1882	114,177,938	221,293			

The exhibits of cane products from these Islands were almost entirely low grades of raw sugar and molasses.

FRANCE.

France made a very fine display of beet sugar in all grades, and prepared for market in many very attractive styles of packing. The displays of transparent crystals and the powdered sugars were interesting, as also was the candied sugar. The great sugar-makers and refineries of France vied with one another in making a brilliant exhibit of their products. The exhibits of the Société de la Sucrerie de Bourdon, of the Raffinerie de Chantenay, the Raffinerie Parisienne, and of Raffinerie C. Say, were all very attractive.

The arrondissement of Cambraï in France had an interesting collective exhibit of the products of the sugar industry in that region. During the season of 1888–'89 there were 28 sugar factories in operation. They employed 4,530 workmen, whose wages were $325,000. There were 371,218 tons of beets worked up, producing 35,888 tons of sugar, 26,000,000 pounds of molasses, 35,353 hectoliters of alcohol, and a large amount of fertilizer material. The expense of working a ton of beets, including cost of beets, wages, etc., is 47 francs.

France consumes annually 450,000 tons of sugar. The average home production of beet sugar is 423,314 tons. This industry has been greatly developed in recent years, as shown on subsequent pages in the discussion of beet sugar.

RUSSIA.

Russia had, next to France, the finest display of sugar in the Exposition. All the grades of beet sugar in its several stages of manufacture were exhibited, as also varieties of sugar beets, and some interesting chemical products of beets. The growth of the sugar industry in Russia has been rapid, and the samples show improvement in methods of preparation. The production of beet roots in 1886 was 5,202,870 tons, but in 1887 there was for some reason a decrease to 4,509,226 tons, though there was an improvement in the quality, which partly compensated for the small yield of roots.

DENMARK.

There were several samples of raw and refined beet sugar from Denmark. The sugar refineries of Denmark, as well as those of France, Germany, and some other countries apparently depend upon Government bounty or high tariff to make the industry profitable.

The exportation of beet sugar, which commenced in 1858 with 690,000 kilograms, is to-day annually nearly 70,000,000 kilograms. A large part of the crude sugar produced is refined in Belgium.

Sugar refining was introduced into Belgium in the sixteenth century. The production of refined sugar and sirups has been as follows:

Average per year from—	Kilograms.
1830 to 1840	18,698,830
1840 to 1850	21,122,132
1850 to 1860	34,454,206
1860 to 1870	30,255,276
1870 to 1880	22,937,282
1886	13,583,840
1887	23,330,823

During these periods the importation and exportation of these products have varied greatly. From 1870 to 1880 the average annual imports were 4,177,736 kilograms and the exports 10,229,404 kilograms. In 1887 the imports were 650,613 kilograms and the exports 16,731,606 kilograms.

BELGIUM.

The beet-sugar industry in Belgium shows great advancement during the past 10 years. In 1888 there were 113 factories in operation that worked 1,350,000,000 kilograms of beets (the yield of 40,000 hectares) and produced 95,000,000 kilograms of sugar and 540,000,000

kilograms of pulp. The statistics of this industry for a series of years are as follows:

Year.	Factories.	Beets.	Sugar.	Pulp.
	No.	*Kilograms.*	*Kilograms.*	*Kilograms.*
1846	25	75,427,250	4,091,005	22,600,000
1856	46	304,018,252	13,300,000	
1866	106	556,100,603	39,132,879	
1876	146	900,000,000	45,628,182	
1888	113	1,350,000,000	95,000,000	540,000,000

GERMANY.

The German Empire is an important source of beet-sugar supply. The harvest in 1889 was 7,896,502,900 kilograms of beets, yielding 861,278,800 kilograms of first and second products, and 24,525,600 kilograms of thirds. The refined sugar made was 456,101,000 kilograms. The consumption in the Empire is about 350,000,000 kilograms, leaving a large quantity for exportation. By great improvements in the methods of manufacture of sugar in recent years, 100 pounds of sugar are now obtained from 900 pounds of beets, when 1,250 pounds of beets were formerly required, and sugar is now obtained also from the molasses. I give below a report of United States Consul-General Raine on the subject of sugar laws in Germany and Austria-Hungary.

In dispatch No. 271, dated July 26, 1887, sent from this consulate-general, the following was reported with regard to German tax on sugar:

"Although by an act approved June 1, 1886, a new classification of sugar and a new method of collecting tax on beet sugar, equaling a reduction of export bounties, was introduced, this act has just been superseded by act of July 9, 1887, to take force and effect on August 1, 1888.

"Section 1 of this new act provides that from and after this date the following rates of import duties shall be collected per 100 kilograms: (1) On sirup and molasses, 15 marks = \$3.57; (2) on other sugar of every description, 30 marks = \$7.14.

"If foreign sugar is consigned to a German sugar factory to be worked further there, the same may, subject to special orders of the federal council, be exempted from the tax of consumption (excise) [hereafter described].

"Section 2 provides that the internal beet sugar shall be subject to a sugar tax, to be collected (1) as 'material tax' [*material steuer*] on the weight of the raw beets intended for the manufacture of sugar, viz, 80 pfennigs (19 cents) per 100 kilograms; (2) as excise (tax of consumption) on the weight of sugar intended for home consumption, viz, 12 marks (\$2.85) per 100 kilograms. This 'material tax' shall be paid by the manufacturer, while the excise shall be paid upon sugar leaving the bonded sugar works or refineries for home consumption.

"Bounties shall be paid—in case of exportation of at least 500 kilograms—for every 100 kilograms, (*a*) for raw sugar containing at least 90 per cent sugar, and for refined sugar containing less than 98 but at least 90 per cent sugar, 8.50 marks (\$2.02); (*b*) for candy and for sugar in white, full, solid loaves, lumps, tablets, cubes, etc., containing at least 99½ per cent sugar, 10.55 marks (\$2.51); (*c*) for all other hard sugar, not otherwise provided for, as well as for all white dry sugar, contain-

ing not more than 1 per cent water, in crystals, pulverized, etc., containing at least 98 per cent sugar, 10 marks ($2.38)."

Also in Austria-Hungary a new sugar law went into effect on the 20th of June last. Both this and the German sugar law are said to have many congruent features, although they differ considerably in several other respects.

The new laws of the German Empire, as well as those of Austria-Hungary, are subjected to much criticism. It is obvious that both are chiefly intended to increase the revenues of the respective governments by subjecting sugar to an excise or tax of consumption. The tax is to be collected in both countries from all kinds of sugar, irrespective of quality, simply by weight, viz, per 100 kilograms: In the German Empire, 12 marks ($2.85); in Austria-Hungary, 11 marks ($2.61).

Both countries retain the export bounty (the efforts of the late sugar conference in London to abolish bounties notwithstanding), evidently for the purpose of guarding against the competition of other nations, especially France, which has become a large sugar-producing rival. A well-informed paper (Die Deutsche Zucker-Industrie, Berlin) says, in referring to the new laws of Germany and Austria-Hungary:

"The modes adopted by both countries differ in their application, though their object is the same. The German Empire retains the beet tax system, with its implicit bounty, by a higher rating of the drawback, but reduces at the same time the tax on beets from 1.70 marks ($0.40) to 80 pfennigs ($0.19), thus lowering correspondingly the present export bounty; while Austria-Hungary frankly allows an export bounty, evading the dual system of taxing one and the same product twice, thus saving much vexation to manufacturers.

"In rating the drawbacks and the export bounty the single-weight system has been abandoned, and a classification is made according to quality, which does not coincide in the two countries.

"In Germany the export bounty per 100 kilograms amounts to:

	Marks.		Dollars.
1. For sugar containing at least 90 per cent sugar	8.50	=	2.02
2. For sugar containing at least 98 per cent sugar	10.00	=	2.38
3. For sugar containing at least 99½ per cent sugar	10.55	=	2.51

Austria-Hungary allows in case of exportation:

	Florins.		Marks.		Dollars.
1. For sugar of at least 88 per cent polarization	1.50	=	2.44	=	0.58
2. For sugar of at least 93 per cent polarization	1.60	=	2.60	=	0.61
3. For sugar of at least 99½ per cent polarization	2.30	=	3.75	=	0.89

"For a comparison between the two countries we must confine ourselves, as for Germany, to classes 1 and 3, and as for Austria-Hungary, to classes 2 and 3, as constituting the bulk of production. For 100 kilograms of raw sugar, for instance, the Austro-Hungarian manufacturer, when exporting such sugar, receives a bounty of 2.60 marks ($0.61), which amount must be paid to him also by the domestic refiner, otherwise the manufacturer would not sell to him. This bounty works like an increase of the price in the world's market by 2.60 marks ($0.61). The manufacturer, therefore, endeavors to produce as cheaply as possible, to pocket the entire bounty whenever the world's market price covers his cost of production. The German competitor, to secure the same amount of bounty, will be compelled to produce a meter centner (50 kilograms) of raw sugar from an amount of beets as low as 7½ (precisely, 7.375) meter centners. Most manufacturers will hardly be able to do so without working up molasses, but the latter increases working expenses considerably per meter centner (50 kilograms), and by these additional expenses the profit of the German manufacturer is diminished. Moreover, he produces a sugar which commands a lower price in the market than sugar manufactured by factories not working molasses. Further, such sugar, especially such as is obtained by means of the *steontianite* (or elimination) process, is liable to the

suspicion of the German excise officials, who subject it to a close examination which, under circumstances, may conduce to a refusal of any bounty whatever, and to a classing of the product with an inferior quality of sugar."

Section 41 of the regulations to carry out the German sugar act of July 9, 1887, says:

"The ascertaining of the contents of sugar by means of a chemical analysis shall be required, if there is reason to believe that the sugar to be taxed contains over polarizing component parts (raffinose, etc.) in quantities comparatively more considerable than is the case with sugar obtained from molasses, especially by way of the *steontianite* (or elimination) process."

The paper from which the foregoing is an extract comes to the conclusion that in Germany, as well as in Austria-Hungary, the new sugar-tax laws will cause much vexation. All factories are to be severely watched, so that no sugar produced and remaining in the respective countries escapes the consumer's tax. In Austria-Hungary stamps are to be attached to all sugar produced at the time the same leaves the factory or enters the public stores. Dealers in sugar are held co-responsible in convincing themselves that the stamp is properly attached whenever they purchase sugar for retailing purposes.

Considerable interest is manifested in watching the effect of the new laws. Doubtless governmental revenues will be increased in both countries, but in industrial circles it is apprehended that the results will not be favorable to a further development of the sugar industry.

EGYPT.

Egypt had only one exhibit of sugar. About three-fourths of the production of sugar cane in Egypt is worked by the factories of the Daïra Sanieh.

The statistics of sugar produced for a number of years are as follows:

Year.	Pounds.	Value.
1877	82,247,200	$4,390,038
1878	87,315,100	3,964,009
1879	68,147,300	2,807,318
1880	75, 34,900	3,582,039
1881	29,044,000	1,441,834
1882	71,496,200	3,301,494
1883	45,539,700	1,905,121
1884	82,632,600	2,900,379
1885	98,677,200	2,855,195
1886	111,493,800	2,946,745
1887	106,959,700	2,724,349

From one of the United States consular reports we learn that:

Ismail Pasha, Khedive of Egypt, now in exile, inaugurated the production of sugar on a considerable scale in Egypt. He acquired large estates for the purpose, and had erected a number of very large and complete sugar mills in Upper Egypt. When Ismail was sent from Egypt and the Khediviate descended to his son Tewfik, the great estates which had been acquired by the former were declared the property of the state, and since then their management has been intrusted to a public administrator known as the "Daïra Sanieh." Two-thirds of all the sugar cane grown in Egypt is produced upon the Daïra Sanieh lands. The lands are leased to fellahs, who are required to plant a certain proportion in sugar cane. The cane is taken for the mills at a price fixed by the administration. All the mills remain under

the direction of the administration, and in them are made all the sugar, molasses, and alcohol produced in Egypt.

The sugar cane produced on other than Daïra Sanieh lands is sold to the Government mills at prices fixed by the administration, and is by them converted into the marketable products.

MADAGASCAR.

The sugar industry has of late years been considerably developed at Madagascar. Some samples of very good quality were among the exhibits of that country.

ALGERIA.

In the instructive collection of agricultural products from Algeria there were some samples of sugar of the date palm made on the irrigated lands of the Agricultural and Industrial Company of Batna and South Algeria.

REUNION.

The sugar industry is the principal one in Reunion Island. There were about twenty exhibits of the raw and refined product in several grades.

The annual yield of sugar cane is from 28,000 to 34,000 tons, which is exported chiefly to France.

MAYOTTE AND COMORES.

The French colonies of Mayotte and Comores exhibited some cane sugar. Wherever France has established her colonies she has encouraged the agricultural industries, and the progress made in the sugar industry since the exposition of 1878, by the improved methods of culture and new processes of manufacture, was very marked in the exhibits from the several colonies.

NEW CALEDONIA.

Some cane sugar from New Caledonia was shown in the Government collection. Efforts are being made to make the cane-sugar industry an important one in New Caledonia, as in adjacent islands.

JAPAN.

Japan showed some candied sugar and some beet sugar. The yield of sugar in 1885 was as follows:

	Pounds.
Cane sugar:	
Raw	79, 112, 099
Refined	16, 611, 748
	95, 723, 847
From Chinese sugar cane:	
Raw	126, 619
Refined	903
	127, 522

Of beet sugar there was a product of 676,847 pounds.

INDIA.

There are about 2,500,000 acres in India cultivated with sugar cane or sugar palms, and the annual yield of sugar aggregates about 2,300,000 tons of cane sugar and 200,000 tons of palm sugar. This annual production of 2,500,000 tons is about the same quantity as the beet-sugar production of Europe, and nearly as much as the total production of cane sugar in other parts of the world. The quality of most of the India sugar, however, is so poor that it can not be marketed in Europe or America in its natural condition, nor could it be substituted for the ordinary sugars worked by the great refineries.

Notwithstanding this enormous yield, it is insufficient for the millions of people of India; each year the imports exceed the exports.

The methods of cultivation are everywhere primitive. With little care the production of sugar might be increased from 2,500,000 to 5,000,000 tons. The quality, too, might be greatly improved. At Madras there are two or three sugar factories equipped with European machinery, and in Bengal there are several refineries where the crude native sugar is partially refined. The possibilities of developing a very extensive sugar industry in India appear to be great.

Sorghum is grown extensively in southern India, but not for its sugar. The seeds are ground into meal as a substitute for wheat, and the stalks serve as fodder for cattle.

French India sent two exhibits of raw sugar and sirups.

COCHIN CHINA, ANAM, TONKIN.

The manufacture of sugar has not made much improvement in Cochin China, the people not yet being willing to adopt the modern machinery.

In Anam the sugar-cane industry is of some importance. In 1887 the exportation of sugar was valued at about $50,000.

The sugar industry of Tonkin produces about $60,000 worth of sugar annually for exportation. About 200,000 pounds of palm sugar are exported annually from Cambodia to Cochin China and Anam. The sirup is obtained from the palm trees by means of incisions in the trees below or underneath the fruit. The sirup is boiled in bamboo tubes and there is obtained a good tasting sweet wine and a black uncrystallized sugar, which is sold in the Cambodia markets in round tablets. The sugar is very sweet and not at all disagreeable to the taste.

CHINA.

China made no exhibit of sugar. Hongkong is the center of the sugar trade, and several refineries are there managed by English capitalists. As the natives of all eastern countries prefer crude

brown sugar to the refined white product the cane is grown extensively in many parts of the Chinese Empire.

JAVA.

In the Island of Java sugar cane is cultivated both by Europeans and by Chinese. In 1887 there were 217 sugar mills in operation. The industry has been carefully guarded by the Government since 1870, and the contracts then made will expire in 1891, yielding to the Government a large revenue for rent of land, tax on production, etc.

In Java, as in the United States and in Europe, on account of the low prices and other causes, there has been a necessity to resort to great economy on the part of the planters and sugar-makers, and the best machinery has been required to make the business profitable. In 1887, the apparatus of diffusion, which has been successfully employed in Brazil, Cuba, and some other countries, was introduced into Java, and it is expected to greatly increase the sugar yield.

Sugar production at Java, 1882 *to* 1887.

	Kilograms.		Kilograms.
1882	293,688,074	1885	382,346,050
1883	325,970,088	1886	387,791,235
1884	396,090,533	1887	410,637,866

PHILIPPINE ISLANDS.

The Philippine Islands produce annually about 175,000 tons of cane sugar. More than half the exports come to the United States. A statement of the present condition of the sugar industry at the Philippine Islands will be found in United States Consular Reports, No. 96.

THE MANUFACTURE OF BEET SUGAR.

The sugar beet is extensively cultivated in Europe, especially in France, Germany, Austria, and Russia, and to a large extent in Belgium, Holland, Denmark, Sweden, Spain, Italy, and England, and the industry is now being developed in Canada, the United States, Chile, New Zealand, and Japan.

The existence of crystallizable sugar in the beet was made known in 1747 by the German chemist Magraff. In 1789 another German chemist, Achard, engaged in the culture of the sugar beet, and in 1796 he bought a sugar factory in Silesia.

The industry was inaugurated in France in 1811 by order of Napoleon, who set apart land for the cultivation of beets and established four royal factories. From the first year's crop about 2,000,000 kilograms of sugar was made. In 1836 there were 436 factories scattered through France, and in 1867 the production of sugar was 216,800,000 kilograms.

There are now between thirteen and fourteen hundred beet sugar factories in Europe, which annually use 25,000,000 tons of beets. Besides sugar, these factories furnish about 8,000,000 tons of pulp used for forage, 2,000,000 tons of fertilizing material, and 800,000 tons of molasses used chiefly for the distillation of alcohol. It is estimated that $100,000,000 per year is paid the farmers for their beets, and $65,000,000 for labor and other expenses of manufacture.

Statistics of production of beet sugar, 1878 *to* 1889.

Season.	France.	Germany.	Austria-Hungary.	Russia and Poland.	Belgium and other countries.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1877-'78	397,873	383,827	350,792	275,000	88,074	1,485,566
1878-'79	432,636	420,684	405,907	265,000	99,926	1,624,153
1879-'80	277,912	411,625	406,375	275,000	83,017	1,453,929
1880-'81	330,061	569,223	498,082	250,000	98,626	1,742,992
1881-'82	391,178	644,775	411,015	308,779	103,156	1,858,883
1882-'83	421,602	848,124	473,002	284,991	117,743	2,147,462
1883-'84	471,234	986,403	455,952	307,697	146,586	2,357,472
1884-'85	316,583	1,154,817	557,766	386,433	330,290	2,545,889
1885-'86	305,683	838,131	370,000	526,200	97,339	2,137,351
1886-'87	497,000	1,015,600	550,000	455,000	141,100	2,658,700
1887-'88	382,563	959,166	400,000	430,000	215,000	2,386,729
1888-'89	474,000	970,000	525,000	500,000	193,146	2,662,146

The following table shows in detail the quantity of beet sugar produced and consumed in the several European countries from 1884 to 1889.

Statistics of production of beet sugar in Europe, and of consumption in producing countries from 1884 *to* 1889.

Season.	France.		Germany.		Austria-Hungary.		Russia, Poland.		Belgium, Holland.	
	Production.	Consumption.	Production.	Consumption.	Production.	Consumption.	Production.	Consumption.	Production.	Consumption.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1884-'85	316,583	408,115	1,854,817	388,674	557,766	235,000	386,433	312,000	130,290	85,000
1885-'86	305,603	403,837	836,131	362,273	370,000	240,000	526,200	328,000	7,337	87,000
1886-'87	497,000	476,328	1,015,600	368,276	550,000	245,000	455,000	344,000	141,100	89,000
1887-'88	382,563	422,891	959,166	432,279	400,000	[illegible]50,000	430,000	360,000	215,000	91,000
1888-'89	450,000	405,400	970,000	452,700	500,000	255,000	500 000	376,000	215,000	93,000
Averages:	390,365	423,3 4	987,542	400,840	475,553	245,000	459.526	344.000	159,819	89,000
Exported	....		586,702		230,533		115,526		70,096	
Imported	32,949		....		....		....		....	

Fifteen years ago the average annual production of beet sugar was 1,256,000 tons; it is now 2,660,000 tons. This great increase is due to various causes.

The markets demanding greater supplies of sugar, the growers have resorted to every means to meet the requirements. Germany and France, tired of contributing to the wealth of other nations by purchasing cane sugar abroad, encouraged the home production of beet sugar. A scientific study of the methods of cultivating the beets so as to secure the greatest amount of saccharine matter, and the study also of the best appliances for extracting the sugar, have during the last decade been very successful.

In the case of France these results are shown in the accompanying tables, from which it appears that with less area planted than formerly, and with a lighter crop, the proportion of sugar has increased from 61.8 kilograms to 106.71 kilograms of sugar per ton (or 1,000 kilograms) of beets.

Production of beet sugar in France during the seasons of 1881–'82 *to* 1888–'89.

Season.	Cultivation of beets for sugar.			Manufacture of sugar.		
	Area planted.	Weight of beets.		No. of factories.	Crude sugar used.	
		Total.	Per hectare.		Total.	Quantity of sugar per ton of beets.
	*Hectares.**	*Tons.*	*Kilograms.*		*Tons.*	*Kilograms.*
1881–'82	183,550	6,329,000	34,481	486	391,178	61.8
1882–'83	197,383	6,911,000	35,013	490	421,602	61.0
1883–'84	195,225	7,139,000	36,568	483	471,234	66.0
1884–'85	152,204	4,608,000	30,275	449	316,583	68.7
1885–'86	119,542	3,385,439	28,320	413	305,683	90.29
1886–'87	151,045	4,897,079	32,302	391	497,000	101.86
1887–'88	137,157	3,614,632	26,354	375	382,563	105.83
1888–'89	150,602	4,223,351	28,000	380	450,000	106.71

* The hectare is 2.471 acres.

Similar statistics for Germany would show results perhaps even more favorable than the above.

The rapid growth of this industry in Germany is doubtless the result of a system of Government bounties, benefiting the best grower and exporter. In 1871 Germany exported 14,000 tons of sugar; in 1879, 138,000 tons, and in 1885, 673,727 tons. The total exportation of German sugar for 17 years aggregates 4,567,000 tons, worth $400,000,000. In Austria, also, there has been a bounty system, which has permitted a rapid growth of this industry.

The great increase in the importation of foreign sugar into France induced the Government in 1884 to enact favorable tariff laws, which immediately resulted in the development of home production and a decrease in imports.

Since 1884, in France especially, there has been a change in the standard of price for the beets. The farmers, too, were formerly

paid by weight without special regard to richness, but now the price is regulated not simply by weight but also by their percentage of saccharine matter. In no branch of agricultural industry more than in this is the advantage of scientific experiment more clearly proved. Numerous experimental stations have been organized throughout France, where are shown the proper methods of preparing the soil, the choice of seeds, the best time for planting, and the nature and quality of the beet fertilizers. The judicious application of the rules approved by the observers at the experimental stations has enabled the farmers to greatly improve the quality of their crops, so that in 1888, as compared with 1883, the beets are very much richer in sugar, and there is much less proportion of impurity.

Perhaps the ablest scientific authority on beet culture in France is Prof. Aime Girard, of the National Agricultural Institute in Paris. The exhibit of the work of this institute at the Exposition was very instructive, especially the charts, models, and other objects illustrative of the improvement in beet culture. Professor Girard has published a valuable work on beet culture, in which he discusses the development of saccharose in the beet, and the best methods of increasing the value of the beets for sugar-making. He shows in an interesting manner that the saccharose is formed by the leaf and its stem, chiefly under the influence of sunlight, and passes through the stalk or stump to the root, which becomes the sugar storehouse. The beets are harvested before the frost sets in, and before they are overripe. In their storage care is taken to prevent them from germination and to protect them from insects. In Russia they are generally kept in trenches or cellars underground. Greatly improved methods of extracting the juice from sugar beets have been generally adopted during the last ten years, and especially during the last five years. The extraction was formerly by presses, more or less perfect, but very much inferior to the method of diffusion now employed.

The diffusion process has diminished more than 90 per cent the losses occasioned by the presses, and has in general proved a great economy.

The proportion of molasses obtained in the process of manufacture has decreased about one-fourth, it now being about 14 per cent instead of 18 per cent as formerly. There is still a considerable proportion of sugar lost.

Ten years ago in France only from 55 to 60 per cent of the sugar contained in the beets could be extracted, but in 1889 improved machinery permits the extraction of 90 per cent.

The operations in making beet sugar are (1) the extraction of the juice, (2) the separation of impurities which prevent concentration up to the point of crystallization, (4) separation of sugar and sirup, (5) treatment of the sirup for additional sugar.

Preliminary to the extraction of the juice, the beets are washed and freed from stones and other foreign matter. There are three processes of extraction, (*a*) rasping and pressing, (*b*) maceration, (*c*) diffusion. The first two methods have now been generally abandoned in favor of the more thorough and economical process of diffusion.

Rasping and pressing.—In the process of rasping and pressing the beets are shredded so as to rupture the greatest possible number of cells containing the juice, and then by pressure to separate the juice. There are many kinds of shredding or rasping machines, but the common principle of most of them is a revolving drum armed with teeth, against which the beets are driven and torn into shreds. The presses are of two kinds, alternating (both screw and hydraulic) and continuous. If to be pressed by the alternating press, the shredded beets are put in woolen sacks containing about ten pounds. After a first pressure under the screw-press, the sacks are generally subjected to a more powerful hydraulic press which extracts much of the remaining juice. In one style of continuous press, that of Poizot and Druelle, the pulp passes between two cylinders carried by endless cloths. A gentle pressing is produced against the first cylinder by the elasticity of the principal cloth in which it is borne. Then, encountering a series of four small rollers, it is seized between the second and first cylinder and deprived of the maximum of juice.

The Champonnois press consists of two permeable rollers partially immersed in a cast-iron tank, forming a water-tight joint with their bases and with the portion emerging at the surface. The pulp can only escape between the rollers. The cylinders are driven in opposite directions. The filtering surface is formed by spinal windings of a triangular thread, with very narrow spaces between the threads.

Centrifugal hydro-extracting machines have been tried for separating beet juice from the pulp of the grated roots, but are little used, for they are incapable of extracting more than 60 to 65 per cent of the juice.

Maceration.—There are many methods of maceration, but as this process—as well as rasping and pressing— is now seldom employed, I shall not enter into details. The principle upon which maceration depends is the dissolving and displacing power of water when applied to the pulp. By Walkoff's method a portion of the juice is extracted by simple pressure or other ordinary appliances, and the pulp is then put in a machine where it passes under a great number of blades which divide it into small fragments, and thus it reaches a large drum supplied with cutting edges that make the fragments still smaller. From the drum the pulp falls into the juice extractor, which is a revolving filter supplied with paddles, and is much like a water wheel. The wheel revolves slowly and causes the pulp to

circulate against a current of water. The exhausted pulp falls into a gutter, whence it is conveyed to store. The water entering the wheel in proper quantity passes successively into each compartment, and is drawn off as concentrated juice. This apparatus is simple and effects almost the complete extraction of the sugar without adding more than 5 per cent of water to the weight of the beets.

Diffusion.—The processes described above depend for their efficiency upon the more or less complete rupture of the cells. Diffusion, on the contrary, dispenses with the breaking up of the cells.

The process of diffusion depends upon the property possessed by the crystalloids of beet juice passing through the cell walls into the surrounding water. Slices of beets being placed in a vessel with about the same quantity of water, the change takes place as follows:

The water forces its way through the cellular membranes into the sugar cells and displaces a portion of the saccharine solution which passes out, thus diminishing the specific gravity of the juice left in the cells, and increasing that of the water outside. This interchange continues until the specific gravity of the water and of the juice in the cells are equal.

By successive introduction of water of less specific gravity, the saccharine solution is finally almost completely extracted, and is in much purer condition than by the older processes of extraction. The first step in the diffusion process is to cut the beets into thin slices, as near as possible of a uniform thickness of about .04 inch, and .4 inch wide.

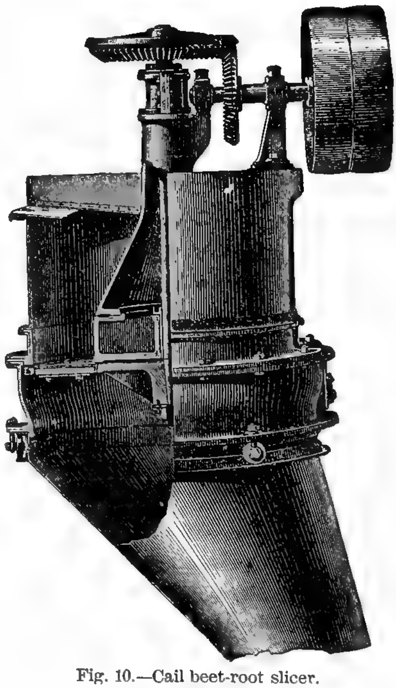
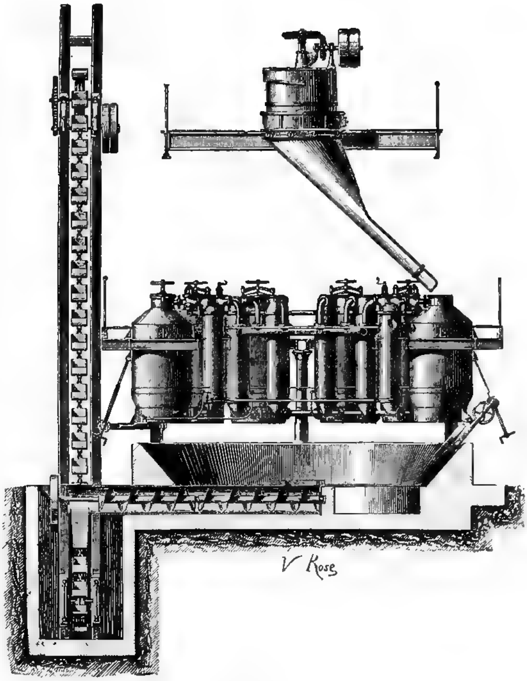


Fig. 10.—Cail beet-root slicer.

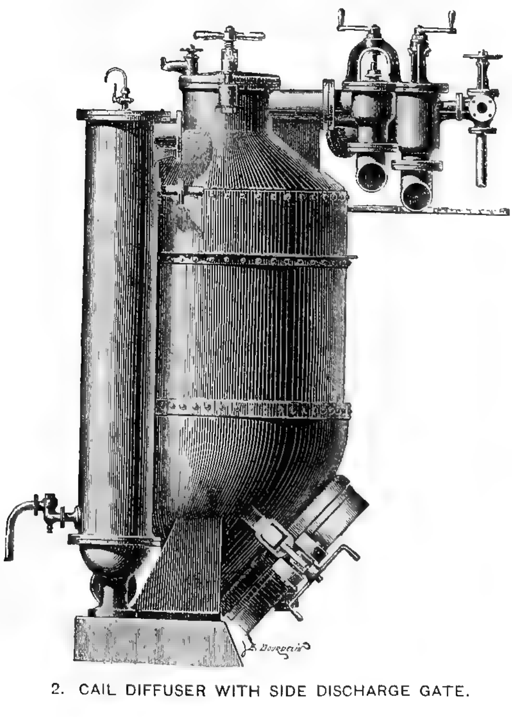
The Cail Company exhibited a full-sized cutter (Fig. 10) for beets, capable of slicing upwards of 250,000 kilograms in 24 hours. The beets are put in a hopper, whence they fall on a cutting plate about 5 feet in diameter, armed with 20 knives, and having 13 inches of cutting edge, the plate making 90 revolutions a minute. From the cutters, the pieces fall through a revolving chute directly into the diffusers.

The beet-cutters exhibited by Alfred Maguiss, of Charmes, France, were adapted both for sugar-making and for distilleries.

The diffusion process as worked by the Roberts system is as fol-



1. CAIL DIFFUSION BATTERY.



2. CAIL DIFFUSER WITH SIDE DISCHARGE GATE.

lows: The slices of beets are put in large, closed vessels, mixed with heated juice (167° to 194° F.) from a previous operation, and exhausted with cold water. The mixture has a mean temperature of about 122° F. Displacement of the juice is performed by a flow of cold water throughout the series of five or eight vessels. The cylinders are furnished at the top with manholes for the introduction of the slices, and through a hinged door near the bottom the exhausted slices fall upon an endless web which carries them away. The cylinders have connecting pipes for the introduction of steam and water. Each vessel receives about 2½ tons of slices, occupying about 132 cubic feet. These slices are not put in until the diffusion water or juice has a temperature of 189° to 207°, the cylinder being about one-third filled with the liquid. The vessel being completely filled with slices and heated juice, the cover is closed and it is allowed to rest for about twenty minutes. Then the pressure of water from over-head tanks is brought to bear upon the nearly exhausted pulp in the last of the series of vessels. As the vessels are joined by pipes, the pressure is exerted upon them all, and the juice is displaced from the cylinder filled with fresh pulp, and proceeds while still hot to the defecating room.

The diffusers exhibited at the Paris Exposition were all of French manufacture. This is unfortunate, for the Germans, Austrians, and Russians have made much progress in the perfection of this apparatus during the last decade, and it would have been instructive to compare the several systems. The two principal exhibitors were the well-known establishments "Compagnie des Fives-Lille," and the "Société Anonyme des Anciens Établissements Cail." The latter exhibitor showed a half battery of diffusers (Pl. LIX). It consisted of six receivers with six heaters. The heaters are arranged so that either live steam or exhaust steam from the other machinery may be employed. A special feature of these diffusers is an improvement in the discharge gate (Fig. 11), easy to manuver and very secure, and so arranged that there is a perpendicular rather than horizontal pressure of the contents, thus, it is claimed, rendering the apparatus safer in case of rupture of the rubber joint.

The diffusers exhibited were of 330 gallons capacity, but they are made to hold from 220 gallons up to 770 gallons. Plate LIX, fig. 2 shows one of the Cail diffusers with the discharge gate on the side.

In France the clarification of the juice is usually by the lime process, which consists in treating the juice from the diffusion battery with milk of lime, heating it, precipitating the lime by carbonic acid, and then repeating the treatment with the decanted juice. In this way, from 30 to 40 per cent of the impurities are removed.

There was at the Exposition an exhibit of some good results obtained by the use of magnesia as a clarifier of beet juice. The clarified juice was formerly filtered through animal charcoal, which de-

colorized it but retained certain salts. Since the adoption of the lime process of clarifying, the use of charcoal has been replaced by filtering through sand, or by the use of filter presses, or mechanical filters.

The refuse from the clarified juice is treated in the filter presses to extract any sugar remaining in it, and the cakes of residuum are used for fertilizing purposes. Many improvements in filter presses were shown at the Exposition. The scum from the defecation of the juice after it comes from the diffusers is passed through a filter press (Pl. LX) composed of a series of cloth bags held against metallic plates pierced with holes. The liquid is forced into the

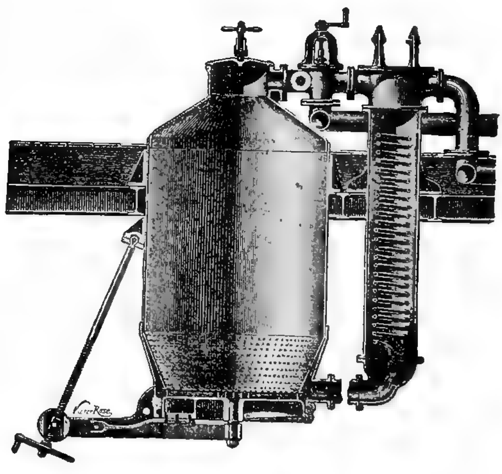
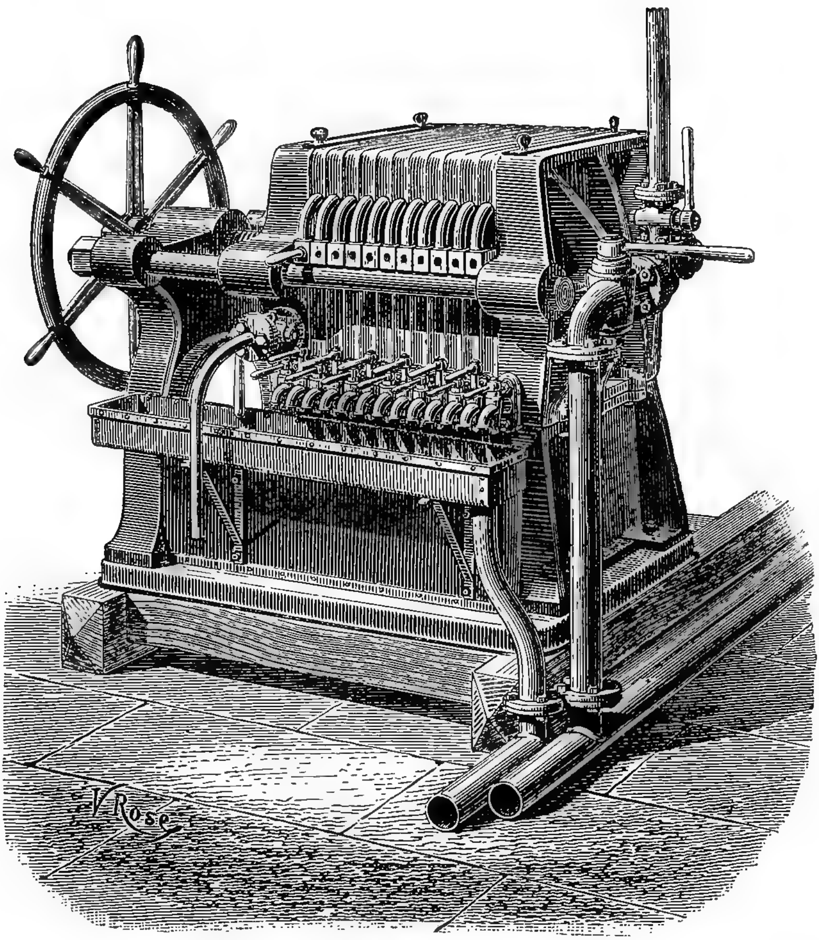


FIG. 11.—Cail diffuser, with improved discharge gate.

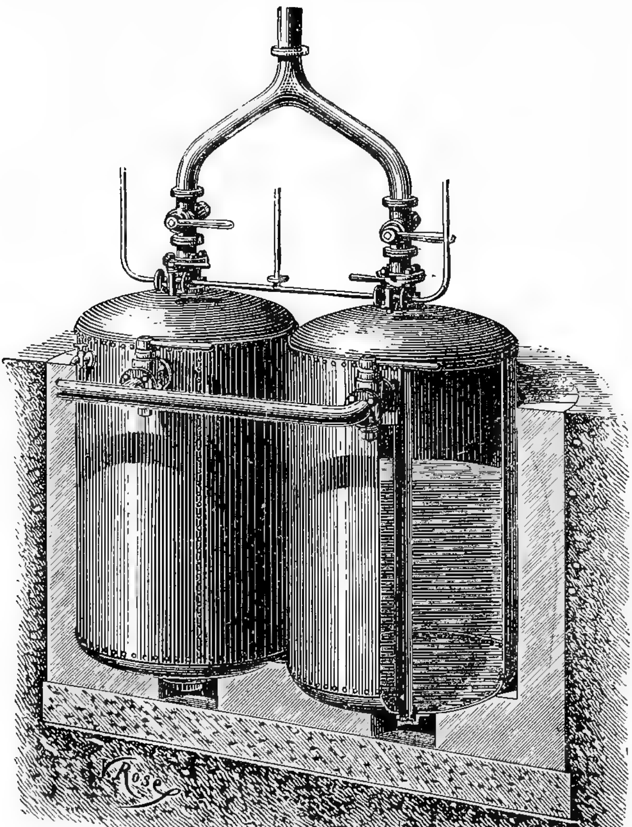
bags and the juice is strained out clear, while the solid scum remains. Steam is then introduced under considerable pressure to thoroughly wash the scum and to dissolve any remaining sugar. In order that the bags may be opened easily, they are formed of two quadrangular cloths put together, the four borders of which are pinched two and two between iron frames, presenting an opening only for the passage of the scum and steam. The frame and, consequently, the set of cloths forming bags are separated by metallic plates, which allow the juice to escape. The juices run along the plates and collect in a gutter. A pump for charging the filter press is shown in Plate LXI.

The firm of J. Holst & Co., of Brussels, exhibited a large double filter press, with 160 compartments, of the Cizek system. The press is shown in Plate LXII. It has a capacity of 400,000 kilograms of beets per day.

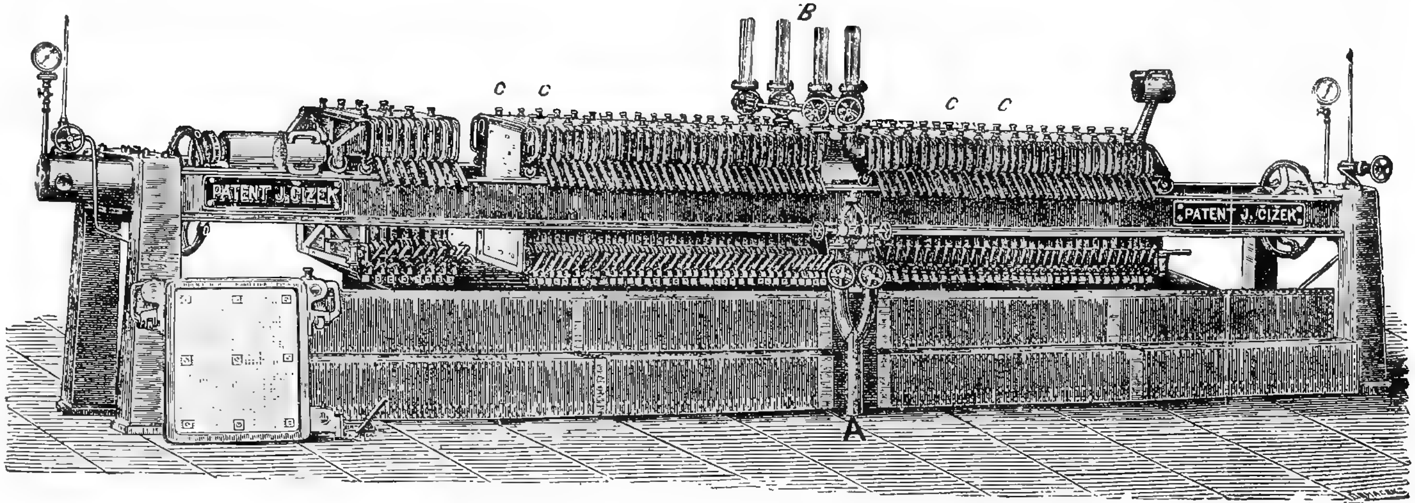
The dregs to be pressed are fed at A; the entrance for water is by pipes B, and each compartment has an automatic valve for the escape of air.



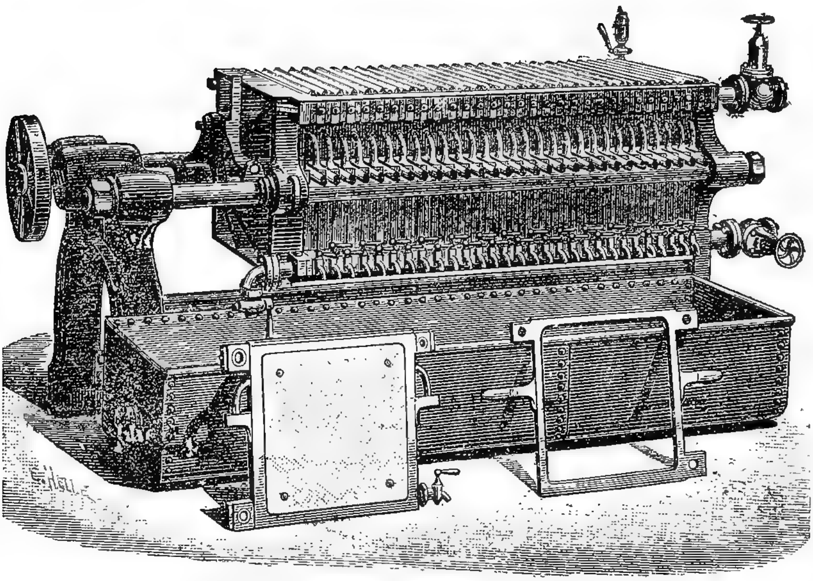
FILTER PRESS, TRINK SYSTEM.



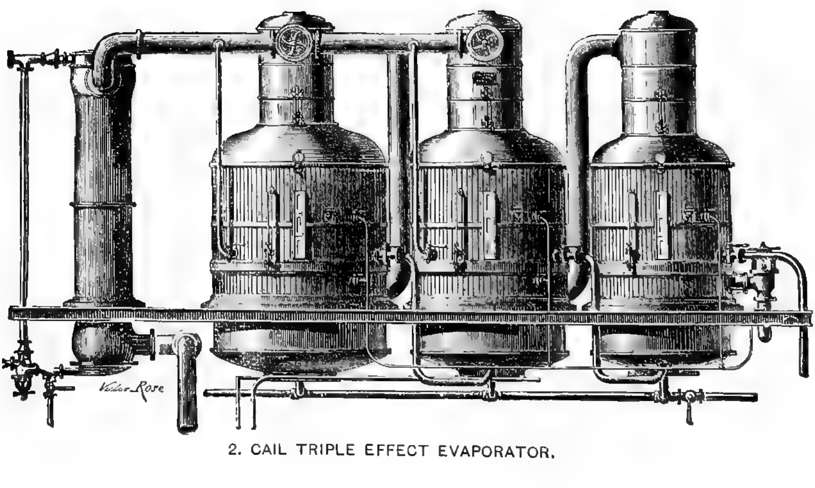
PUMP FOR CHARGING FILTER PRESS.



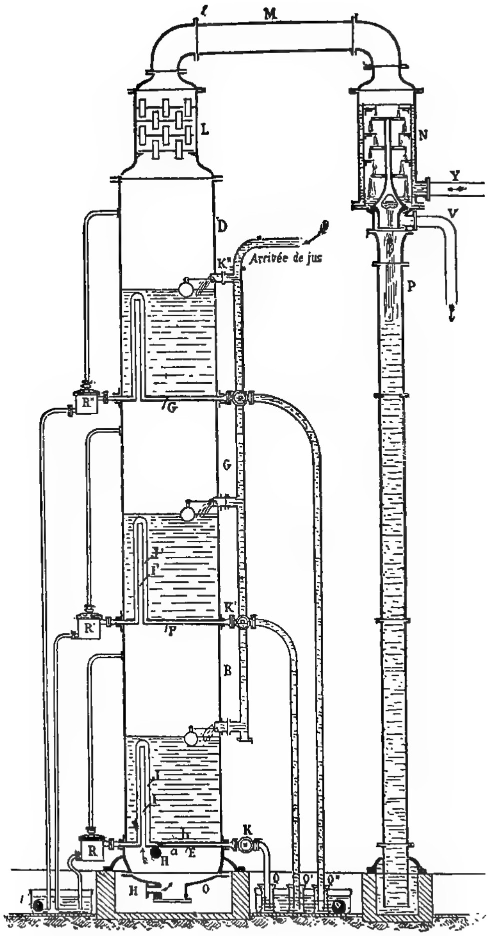
CIZEK FILTER PRESS.



1. VILLETTE FILTER PRESS.



2. CAIL TRIPLE EFFECT EVAPORATOR.



MARIOLLE-PINQUET TRIPLE EFFECT APPARATUS.

The well known Villette filter press (Pl. LXIII, Fig 1) was exhibited by Montanban & Marchandier. They are made with plates 25 to 40 inches square. The frames and plates have three canals, one for the entry of the material to be pressed, one for water, and a small exit for the escapement of air. The skimmings from the clarified juice enters the several compartments of the machine under pressure, and the solid matter forms in cakes between, while the liquid is forced through the perforated plates and out of the press.

Water is then forced through and the cakes then washed from any remaining juice.

After the clarification and filtration are completed the sugary liquid is submitted to the process of evaporation to reduce the juice to sirup. This is done in the vacuum apparatus of double, triple, or quadruple effect. The system is based on the property that some sweet liquids possess of boiling in a vacuum at a temperature lower than 212°. The juice is heated by means of exhaust or waste steam strengthened, if necessary, by live steam. The double effect system was until recent years much used in Germany and Austria, but they have now adopted the triple effect evaporators which have been used in France since 1865.

The triple effect evaporator exhibited by the Cail Company (Pl. LXIII, fig. 2) has a capacity of 52,800 gallons of juice per 24 hours. It is composed of three differential heaters, having 384 square yards of heating surface. Its principle is based on the employment of exhaust steam from the various machines in the sugar factory, which permits of an economy of 40 to 50 per cent in fuel.

A system of triple effect apparatus was exhibited by a French manufacturer, Mariolle-Pinquet, which is illustrated in Pl. LXIV. It consists of three tanks, each 9 feet high, superposed and separated one from the other by tubular plates. The upper tank communicates with a condenser. The steam enters the apparatus by the tube H under the tubular plate E, penetrates the tubes I, is expanded at the upper part and descends by some inner brass tubes, and is condensed and flows out through R. The juice enters by the tube K. The action of the steam in the second and third tanks is the same as in the lower one.

The whole apparatus is simple and designed especially for use on the sugar plantations of the French Colonies.

The juice, having been reduced to sirup by the evaporators, is cooked in the vacuum or strike pans until it becomes a crystalline mass, called "*masse cuite.*"

The cooking apparatus is generally a sheet iron or copper pan fitted in a cast iron steam case with steam space left between, and is surmounted by a copper dome. The pans and dome are bolted together so as to be air and steam tight throughout.

At the top of the dome is a man-hole, with a gun-metal cover, and

connected with the top is an arm pipe opening into the receiver. A steam valve opens into a copper steam worm in the lower part of the pan. The worm gradually diminishes in size from the valve to its exit at the bottom of the pan. There is a pipe to carry off the water from the steam case, and a slide valve for discharging the sugar. The dome of the pan is mounted with a vacuum guage, thermometer, and a sight glass, and proof stick to test the contents.

The Cail Company exhibited a vacuum pan shown in Plate LXV. This boiler is of sheet iron and has a diameter of 9 feet, and is fitted with a system of compound valves, so that either direct steam may be admitted at will into any number of the six serpentine coils, while the rest of the coils receive exhaust steam. The boiler is eight feet high, and permits of obtaining large crystals of sugar. In feeding the vacuum pan, sirup is admitted gradually as the crystals of sugar form, and the operation is carefully watched. The capacity of the pan exhibited was 2,600 gallons.

After the crystallization has gone on as far as possible the *masse cuite* is drawn from the vacuum apparatus. The next operation is to separate the crystals from the sirup or molasses. This is done in centrifugal machines.

The centrifugal is charged with the *masse cuite*, and is made to revolve rapidly until the contents are a reddish color, when, without stopping the rotation, some pure sirup is poured in, and the mass assumes a clear yellow tint. Dry steam is then injected, and the sugar becomes perfectly white. This is called first jet or throwing. About five-sevenths of the total sugar available in crystallized form is of this grade.

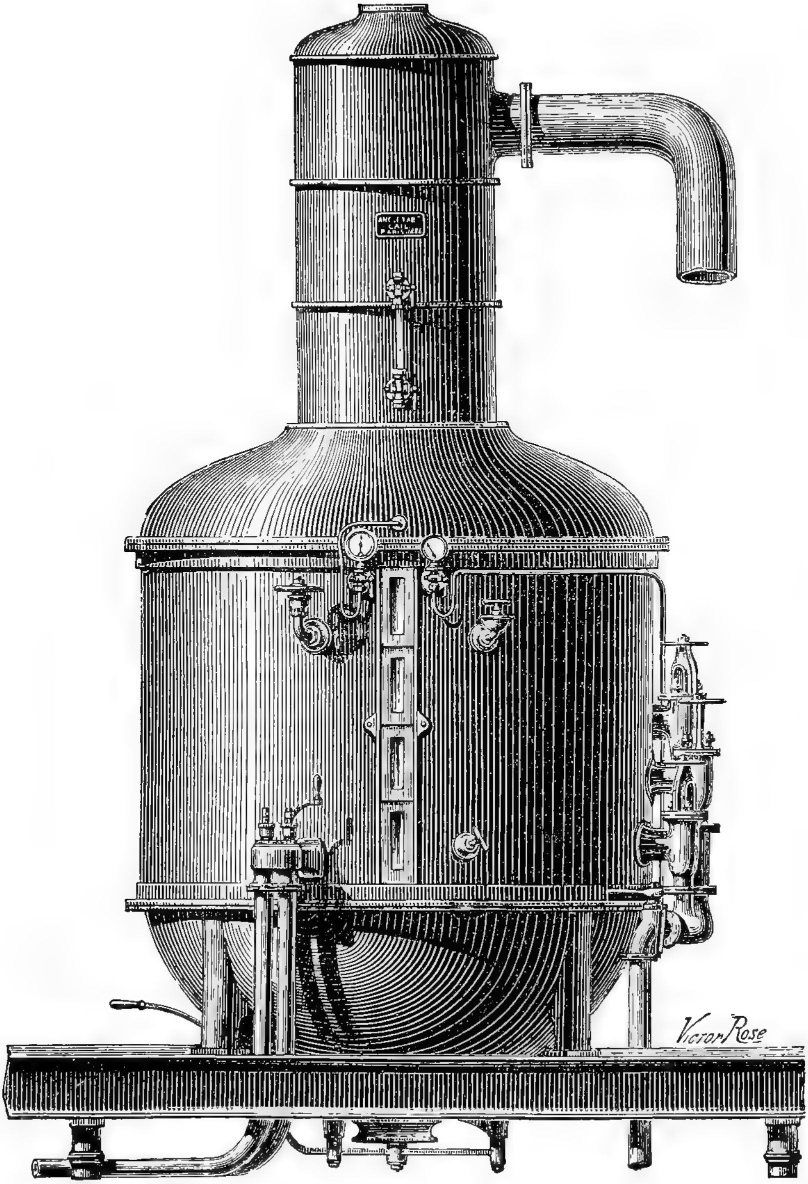
The liquid flowing away is run into tanks, reheated, filtered through charcoal, boiled to a stringy consistency, and is then submitted to the centrifugal, either alone or with some pure sirup, and yields sugar of the second jet. The molasses drained off is stored in immense tanks in a room heated to 104° F., and at the end of a year or so is put through the centrifugal, yielding sugar of the third jet.

The first jet sugar is known as white, grain, ordinary, or brown sugar, according to the method employed. The second and third sugar is sold to refineries to be further purified and made into loaves, tablets, etc.

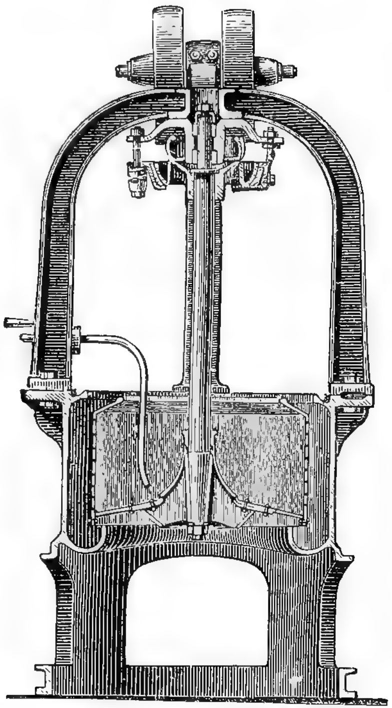
It is very difficult to distinguish between the grain sugar from beets and that from sugar cane, but the brown beet sugar has an odor peculiar to itself which prevents its sale until it is refined.

An ordinary centrifugal machine and the Weston-Cail centrifugal are shown in Plate LXVI.

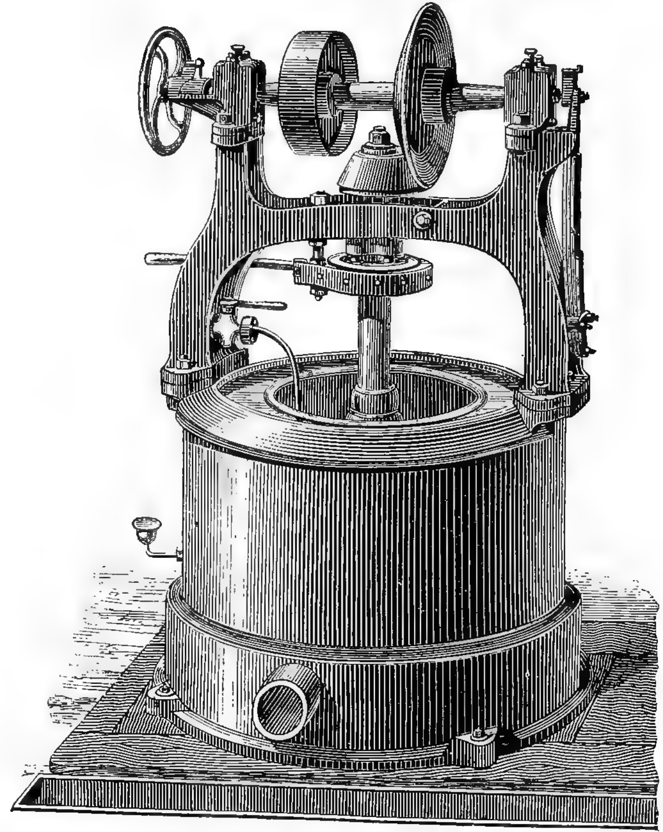
Several styles of centrifugals were exhibited which were intended to clarify the sugar and make it into blocks. The Cail Company exhibited the Tietz Selwig and Lange centrifugals (Pl. LXVII) for the use of sugar-makers, by which the crude product may be directly transformed into cakes of refined commercial sugar.



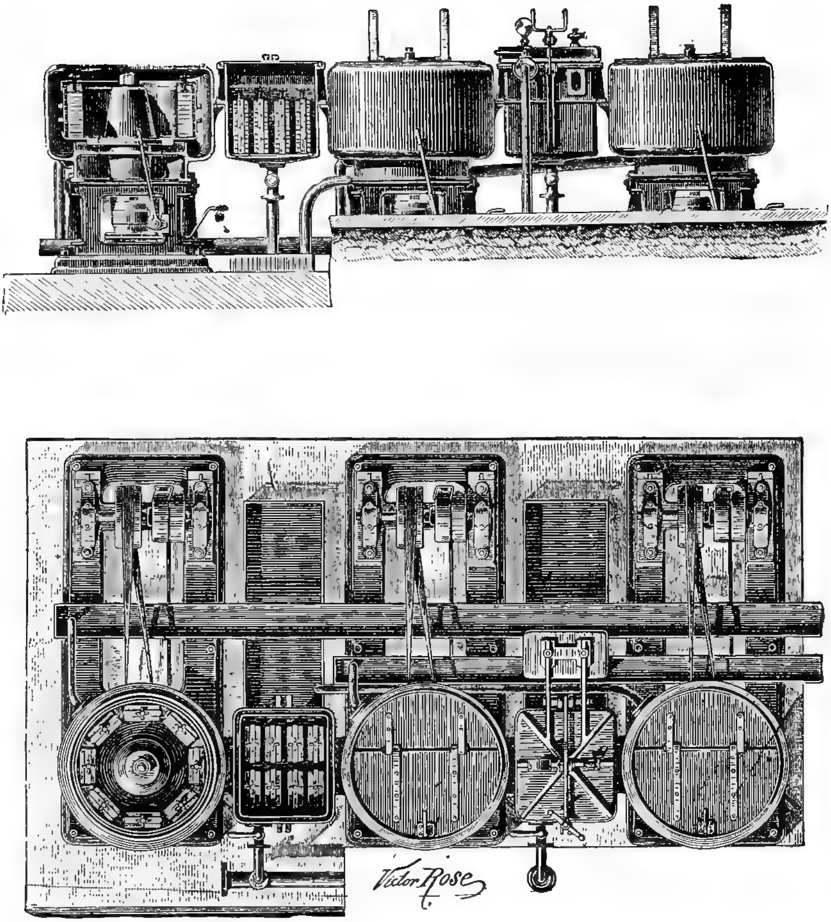
CAIL VACUUM COOKING PAN.



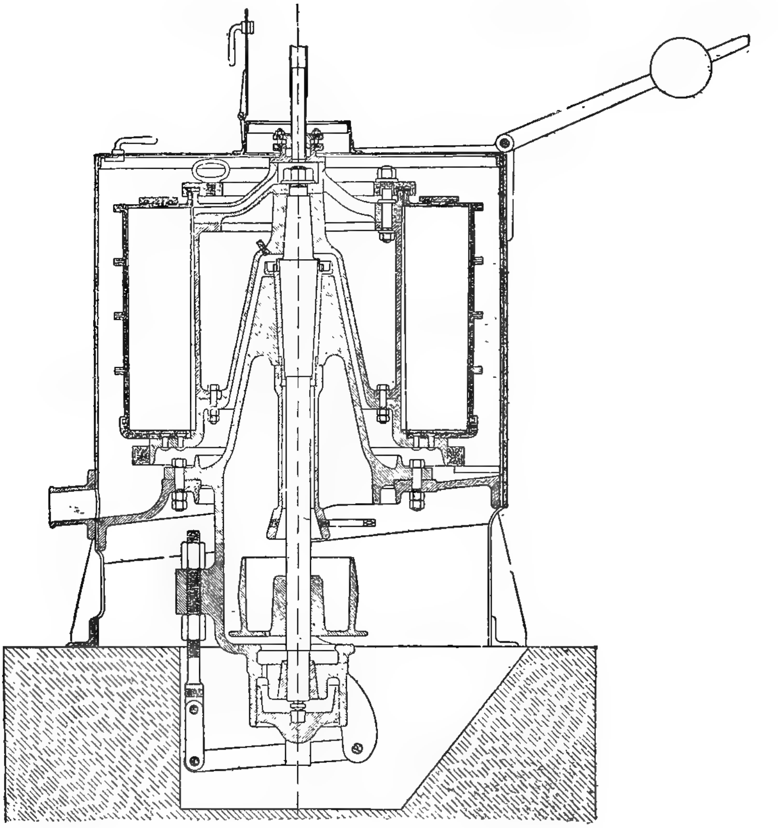
1. WESTON-CAIL CENTRIFUGAL FOR REFINING.



2. CAIL ORDINARY CENTRIFUGAL.



CENTRIFUGAL OF TIETZ, SELWIG & LANGE PROCESS.



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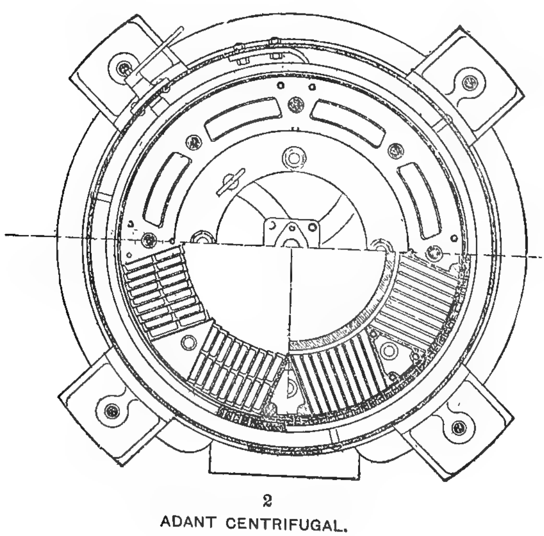


2

ADANT CENTRIFUGAL.

Many machines have been invented in the United States to accomplish the same result as the above centrifugal, and some of them, perhaps, of superior construction.

In operating the Tietz process there are three centrifugals and two refiners. The crude brown sugar is melted and then boiled down to a suitable consistency to be placed in metallic forms that are arranged around the interior of the first centrifugal. When the flow of sirup is exhausted by the action of the centrifugal, the forms are placed in the first refining receiver and purified with pure sugar from the third centrifugal. The forms are then put in the second centrifugal, the sirup exhausted, and the sugar again purified and turbined in the third centrifugal. The cakes of sugar are now dried in an oven.

The Compagnie des Fives-Lille and H. Vivien also exhibited centrifugals intended to accomplish the same results as the Tietz machines. In these machines, separating apparatus for refining are not employed, but pure sirup is admitted directly into the centrifugals.

The forms of sugar are about 8 inches square and one or more inches thick, that may be readily cut into the commercial cubes. By these machines it is claimed that in 48 hours refined sugar, in salable condition, could be made, which by the usual methods could be finished only in 15 to 16 days.

A design of the Adant centrifugal was exhibited by Jean & Peyrusson (Pl. LXVIII), and also some samples of the refined sugar made by this process. The construction of the apparatus is different, but the operation is much the same as the machine described above. The heated *masse cuite* is run into annular forms, containing a mold divided into several compartments that are subdivided into smaller sections of the thickness desired for the blocks of sugar.

After being cooled, the forms of *masse cuite* are put into the centrifugal, and the sirup forced out, and at the same time clear juice is admitted to purify the sugar.

The usual yields in making beet sugar are, for 100 pounds of beets, about 5 pounds of first grade-sugar, 1½ pounds of second grade, and one-half pound of third grade. This may be tabulated as follows:

	Pounds.
First grade	5.00
Second grade	1.50
Third grade	0.50
Molasses	1.50
Losses:	
Sugar in the pulp	0.50
Sugar in the scums	0.35
Sugar lost in the filters	0.59
Miscellaneous	0.06
	10.00

TREATMENT OF MOLASSES.

Beet sirup, or molasses separated from the sugar by the centrifugal machines, contains about 50 per cent of sugar retained by the pressure of salts and organic materials. Much study has been given to discover an economical method of eliminating the nonsucrous properties. Among the processes proposed are the osmose process, the strontian process, the elution process of Manonry, and the Sostmann process.

Plans for working by the Sostmann process were exhibited by the Cail company. It is claimed that 80 per cent of the sugar may be extracted from the molasses by this method. Lime and alcohol are used. To work 100 kilograms of molasses requires about three pints of alcohol.

The osmose process is based on the same principle as the process of diffusion, the salts contained in the molasses diffusing much more rapidly through a porous diaphragm than sugar. The difference of time is not sufficient to enable direct separation to take place. At first, the membrane is traversed by much salt and little sugar, but later the reverse is the case. The "osmogene" used in this process consists of two chambers separated by a diaphragm made of parchment paper. One chamber contains the molasses and the other is filled with water.

By the elution process the sugar of the molasses is converted into tribasic sucrate of lime, by mixing the molasses with about a quarter of its weight of lime, when the mass solidifies. It is then treated with water to remove the organic matter, while the sucrate of lime remains solid. This solid is then carbonated, like lime juice, and gives a sirup containing 33.7 per cent of sugar and 5.7 per cent of impurities.

The strontian process is employed in some of the largest refineries in France and other European countries. The sugar is separated from the molasses in the form of sucrate of strontia, which is further treated to remove the mineral base.

THE MANUFACTURE OF CANE SUGAR.

The cane-sugar industry is much older, and yet it is far behind the beet-sugar industry in improved methods of culture and in machinery. While the quality of beets has improved from 20 to 40 per cent in possible yield of sugar, there has been little, if any, improvement in sugar cane.

The great sources of supply of cane sugar during a series of years are shown in the following table. Cuba stands first and the United States is fifth in importance. Other countries not specifically mentioned, but which are engaged in the culture of sugar cane, are the Central American States, Mexico, the Argentine Republic, Venezuela, Mayotte, Siam, Cochin China, Japan, and Spain.

Statistics of total production of cane sugar in the world, 1878 *to* 1886.

[Tons.]

Years.	Java.	Dutch and French Guiana.	Cuba.	Manilla.	Porto Rico.	Brazil.	Mauritus.	British India.	Natal.	Jamaica.
1878	217,000	7,823	474,427	118,141	84,347	120,918	139,608	46,074	7,540	18,247
1879	182,844	11,634	623,934	128,748	76,411	161,788	134,800	18,705	3,055	25,156
1880	235,178	10,609	495,831	181,520	57,057	218,582	87,302	18,942	11,881	27,710
1881	249,393	8,988	449,067	210,160	61,715	194,516	118,210	32,710	8,718	18,166
1882	295,083	9,794	538,388	153,780	80,066	131,397	117,722	72,479	8,000	38,968
1883	301,970	10,193	412,890	212,719	77,632	226,709	116,612	72,489	9,783	26,558
1884	338,886	7,228	560,934	122,925	98,665	268,335	120,539	82,749	17,172	29,868
1885	396,372	5,430	631,967	203,490	70,000	190,000	127,540	54,349	16,000	25,361
1886	328,577	6,283	731,723	181,148	63,914	249,821	114,198	59,253	13,250	25,000

Years.	Barbadoes.	Trinity.	British Guiana.	Australia.	Louisiana.	Martinique.	Guadeloupe.	Reunion.	Egypt.	Total production of cane sugar.
1878	40,859	52,908	77,469	10,831	112,093	44,218	48,118	40,610	37,512	1,698,743
1879	48,720	67,868	95,079	16,105	108,114	46,869	47,634	33,032	33,616	*a*1,944,106
1880	46,863	54,237	97,684	26,867	88,822	38,593	41,321	21,176	34,755	*a*1,874,930
1881	45,067	44,375	92,311	26,475	121,867	42,090	42,275	27,373	32,000	*b*1,860,476
1882	46,360	56,265	124,102	34,500	71,373	47,888	57,511	25,059	26,377	*c*2,016,084
1883	45,836	55,420	116,636	51,500	137,327	46,857	51,619	33,020	21,597	*d*2,104,072
1884	53,722	61,875	125,522	59,869	128,443	49,370	55,257	37,800	37,587	*e*2,547,531
1885	56,200	64,634	96,058	87,245	94,375	38,786	41,131	37,973	45,035	*f*2,592,647
1886	40,780	49,175	111,855	87,000	127,958	30,199	36,678	34,732	51,700	*g*2,702,850

a Includes 80,000 tons for Peru in 1879 and 1880.
b Includes 35,000 tons for Peru.
c Includes 30,000 tons for Peru and 50,972 for Hawaii.
d Includes 25,000 tons for Peru and 51,705 for Hawaii.
e Includes 6,529 tons for Peru, 63,948 tons for Hawaii, and 113,613 tons for China.
f Includes 31,719 tons for Peru, 76,496 tons for Hawaii, and 93,657 tons for China.
g Includes 35,000 tons for Peru, 92,050 tons for Hawaii, and 86,586 tons for China.

Within the last three to five years many important improvements have been made in cane-sugar machinery, especially in the method of extracting the juice.

The mills and presses are now giving place to the modern apparatus of diffusion. The diffusion process was first employed in extracting sugar remaining in the bagasse, or crushed cane, as it comes from the mills, but now it is made applicable to the cane itself. In Spain this process has for several years been used in the manipulation of the bagasse, and the juice thus obtained is mixed with that extracted directly from the cane. The result is an improved quality of juice, and economy of production.

The Spanish cane is less rich in sugar than cane grown in other countries, and the use of mills for the cane and the process of diffusion for bagasse is found more economical than the diffusion process alone.

Sugar cane contains about 88 to 90 per cent of juice by weight. With the ordinary mills, about 65 per cent of juice may be extracted, and by using a shredding or defibering apparatus, the proportion may be increased to 75 per cent. By the adoption of the improved process of diffusion, it is now possible to extract 85 per cent of the juice from the cane, and the product is purer and richer in sugar.

In working 440,000 pounds of cane, the loss with the ordinary crusher (extracting 65 per cent of the juice) is 16,852 pounds of sugar; with the improved crushers (extracting 75 per cent of the juice), the loss is 9,548 pounds of sugar, and with the diffusers (extracting 85 per cent of the juice), the loss is 2,200 pounds of sugar.

The juice in sugar cane is inclosed in little cells which are surrounded and protected by woody matter which forms about one-tenth the weight of the cane. To extract this juice one of three methods may be employed: (1) break the cells so that the contents may flow out; (2) combine the crushing process with maceration (3) utilize the cell walls as a membrane by the process of diffusion.

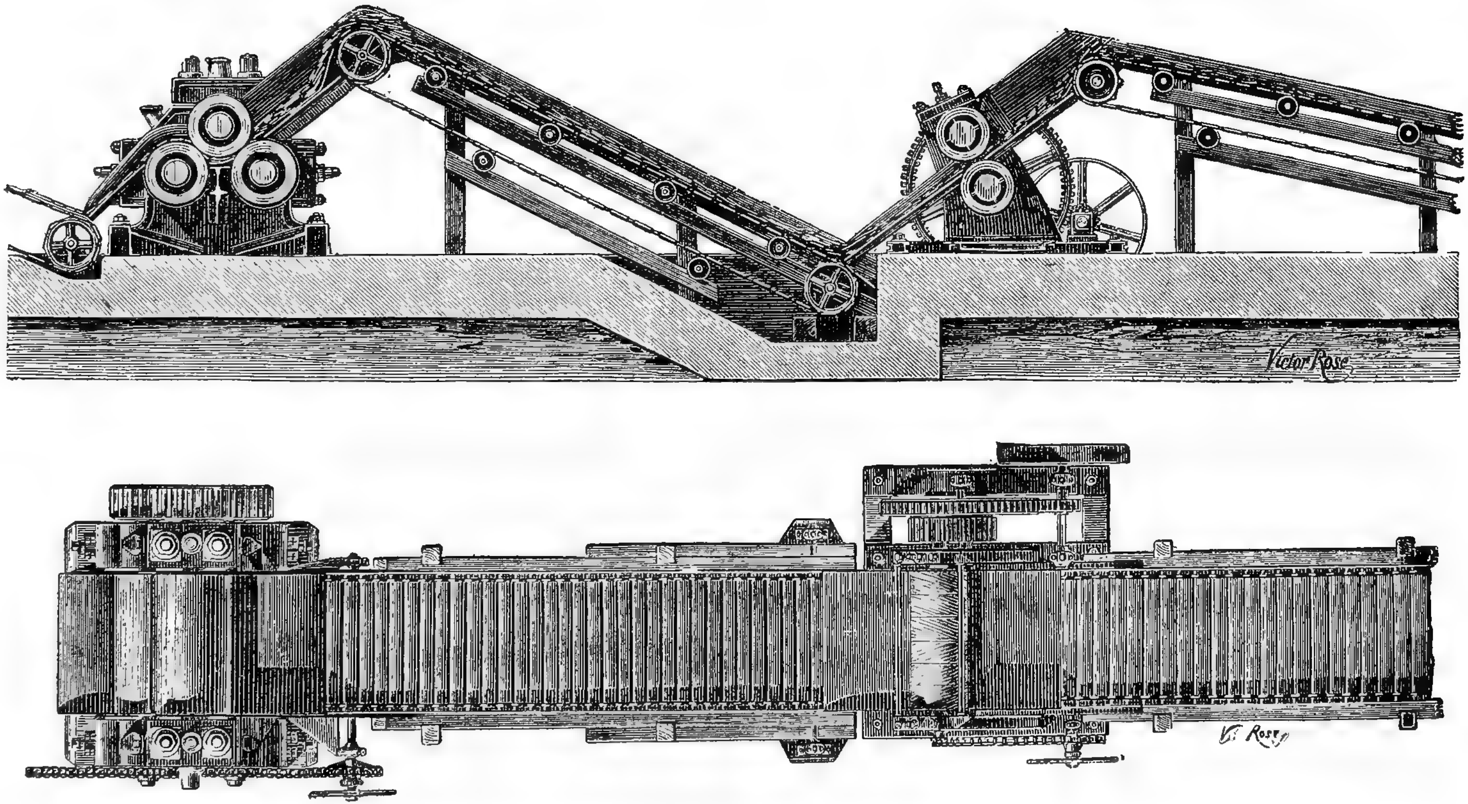
The first method, that of breaking the cells, is accomplished by crushing machines. The styles of mills invented and used have been very numerous. At the Paris Exposition only a few kinds were exhibited, and those were of French manufacture only. They are rapidly going out of use, though very many are still employed in various parts of the world.

The mills are made with from two to nine cylinders, which vary in size in different machines. Some have small cylinders that revolve rapidly, while others have large cylinders revolving slowly.

The second method, a combination of crushing and maceration, sets free a greater percentage of juice and is, therefore, better than the simple crushing. Messrs. Rouant Frères & Co., of Paris, make a defibrator not, however, shown at the Exposition, which reduces the cane to pulp, and by subsequent pressure 77 per cent of the juice is separated by the first crushing, and a further 25 per cent on the weight of the bagasse by a second crushing.

An improved defibrator was exhibited by Pierre P. Faure, of Limoges. In this machine a shaft carries a cylinder whose surface is provided with teeth running in a helical direction. A drum of polygonal form is keyed to the shaft, and to the drum are attached the toothed defibrating plates. By this machine it is claimed that as high as 78 to 82 per cent of the juice has been extracted.

By saturating the cane with hot water or steam, either before crushing or after a first crushing and then recrushing, more juice may be extracted than without such saturation. In Duchassaing's process, the cane is crushed, yielding 68 per cent of juice, and the bagasse is then soaked in boiling water and passed through a second mill. Until recent years sugar-makers used only the crushing mills of these cylinders, then they began to recrush the bagasse, as



CANE DEFIBRATOR AND MILL.

mentioned above, and finally they adopted crushers of even eight or nine cylinders. One of these compound mills, made by Brissoneau, Derouable et A. Lotz, of Nantes, was exhibited at the Exposition.

The Cail Company exhibited a defibrating machine used in connection with the crushing cylinders, as shown in Plate LXIX.

In the French section of the Exposition there were full installations of all the most improved machinery used in sugar-making, especially the modern apparatus of diffusion which the first sugar-growing countries are rapidly adopting. In Java, Australia, Brazil, Cuba, the Gaudeloupe, the United States. and elsewhere, the diffusers are now fully established.

A complete outfit for working sugar cane by the diffusion process, as manufactured by the Compagnie des Fives-Lille, costs about $30,000 and consists of (1) an elevator for the cane; (2) two cane-cutters; (3) an elevator for the chips; (4) a movable receiver or hopper for filling the diffusers; (5) receptacles for the juice and elevators for the exhausted chips; (6) an air pump, and (7) a horizontal steam engine with connection for working the various machines. This equipment, as usually set up, occupies a building about 75 feet long and 45 feet wide, or the cutters and diffusors may be placed in adjacent buildings.

There are very many kinds of cane-cutters, but only a few, and those of French manufacture, were shown at the French Exposition. The object of the machine is to cut the cane in diagonal slices 3 or 4 inches long, and about one-sixteenth of an inch thick. One of these machines, made by A. Jouin & Co., of Paris, consists of a disk, the periphery of which is formed like a truncated cone, either simple or double, is armed with a series of blades whose inclination with that of the periphery is such that the sliced matters are driven by centrifugal force away from the wheel. A pair of feed rollers, placed in front of the disk, pass forward the canes to be cut.

The cane-cutter exhibited by the Compagnie des Fives-Lille had a capacity of 40,000 kilograms of chips per 24 hours. It was worked by steam power. In this machine the canes are fed into eight compartments, inclined so that the ends of the cane rest sideways on a movable horizontal platter, about 7½ feet in diameter. The platform is armed with sixteen knives, and as it revolves, the cane—pressed by its own weight against the knife edges—is cut into pieces that fall into a trench below.

In the Roberts system of diffusion the vessels are of light boiler iron with cast-iron bottom. They measure 120 cubic feet and contain 4,200 pounds of cane chips and 3,250 pounds of water, ten forming a battery. Each vessel has five pipes, for water, to send juice to the heater, to receive juice from the heater, to discharge juice into the clarifiers, and to pass juice from one vessel to another, besides one direct from the boiler for steaming purposes, and one

for discharging the water from the vessel before emptying the exhausted chips. At the top of each vessel there is a manhole to receive the chips, and another, 4 feet square, near the bottom for discharging the exhausted chips. The juice is drawn from the vessel through a perforated false bottom. The heater, made of boiler iron, connects directly with the steam boiler, and is used to heat the juice on its passage from one diffusor to another, as it traverses a system of copper pipes completely surrounded by steam. Hydrostatic pressure is used in passing the juice from one vessel to another through the heater and into the sugarhouse; this is obtained by the force of water from a tank of about 1,500 gallons capacity placed 20 feet or more above the diffusors. The diffusor vessels are arranged in a circle, being fed by a revolving feeder. When one diffusor is filled with chips, and while the next is being filled, steam is let in until it escapes from the top. The steam is then shut off and water let through the heater until the vessel is full, when the top is closed.

The second vessel being filled with chips, steamed water is again let down from the tank through the heater in the first vessel, driving the liquid through the connecting pipe into the second vessel. The next vessel is filled, steamed, and charged with juice in the same way. When the fourth vessel is filled with chips, cold water is let directly from the tank into No. 1, driving the juice which was in it through the heater into No. 2, and from 2 to 3, and 3 to 4. Cold water is then run into No. 1, and from 1 into 2, from 2 through the heater into 3, then directly from 4 to 5 and so on, care being taken to keep the temperature of the last vessels filled at about 190° to 200° F. The hot juice is sufficiently concentrated when it has passed through No. 7, and is drawn off. The first vessel is then emptied of the exhausted chips and No. 2 becomes the first of the battery, and the work goes on as before, there being always seven vessels working, one emptying and one refilling.

It requires about a ton of water to work 1 ton of cane, and care must be taken to have pure water, for impurities in the water affect the quality of the juice.

Juice obtained by diffusion takes longer than mill juice to crystallize when brought to sirup. The continued high temperature required in the diffusion process is said to make an excess of sugar by converting the crystallizable into uncrystallizable sugar.

After the juice has been extracted from the cane, it must be freed from impurities. This may be accomplished by heat, by chemicals, or by filtration. Heat alone checks acidity and aids the action of chemicals on the juice. Several kinds of steam clarifying apparatus were on exhibition, two of them by Cail & Co., but there was nothing novel in their construction or action.

Of chemicals, the best and most widely used clarifier is slacked

lime. Next in importance are bisulphite of lime, sulphurous acid, lead acetate, and some special compounds.

Juice extracted by the diffusion process is very much purer than mill juice and is more easily clarified. Within a few years successful experiments have been made in removing the impurities by the introduction of milk of lime directly in the diffusion vessels, thus saving one step in the process of sugar-making. Filtration of the juice is generally necessary to remove the matters made insoluble by heat and chemicals employed in the operation of clarification. The principal methods of filtering are by bag filters, charcoal filters, or by capillary filters. The capillary or mechanical filters are now much used, being more economical and equally as effective as the charcoal or bag filters. Several improved systems of mechanical filters were exhibited.

Curing embraces the drying and whitening or bleaching of the sugar. The oldest and crudest method is simple drainage, by placing the *masse cuite* in casks with perforated bottoms, the holes loosely filled with canes, twisted leaves, or rushes. Sugar cured in this way is called "muscovads," and is the most impure of brown sugar.

Washing the *masse cuite* with water effects considerable purification, the impurities being more soluble than the sugar itself. A gradual percolation of water is effected by the process called "claying," the sugar being put in inverted cones, with a small opening in the apex. The hole is stopped up while the cone is being filled, and for several hours afterwards. A batter of clay and water is put on top of the sugar, and the water gradually works its way through the sugar and carries with it the uncrystallizable sugar and the coloring matters.

Sugar is not very soluble in alcohol, but many of its impurities are readily soluble and may be driven out by the method of "spirit washing." This is an effective, but an expensive, process of curing sugar.

A vacuum chest has been sometimes used to separate the sugar and molasses, the *masse cuite* being placed on a tray in the upper part of the chest, and the uncrystallizable portion drawn through the tray by the action of an air pump attached to the bottom of the chest.

The centrifugal or hydro-extractor is the apparatus now almost universally employed for curing sugar. The general construction of a centrifugal is a cylindrical basket revolving on a vertical shaft, its sides being of wire gauze or perforated metal for holding the sugar. The basket is surrounded by a casing at a distance of about 4 inches, the space thus left being for the reception of the molasses, which is expelled by centrifugal force through the sides of the basket when it revolves at high speed.

CONCENTRATION AND GRANULATION.

After the solution of sugar ana water has been freed from impurities by defecation and filtration, the excess of water must be removed so as to allow the sugar to assume a crystalline form. This may be accomplished by either heat or cold, but heat is generally employed. The principal methods of applying heat are (*a*) pans heated by fire or by steam, (*b*) film evaporators, (*c*) vacuum pans.

The pans heated by fire are now employed only where improved apparatus is not obtainable. Steam pans are usually of wrought iron, furnished at the bottom with a series of copper steam pipes to heat the liquid.

The film evaporators depend upon the principle of exposing thin films of liquid to the action of a heated surface in the open air. There are several forms, consisting of revolving cylinders partially immersed in the liquid and heated instantly by steam. Instead of a cylinder a revolving steam coil is sometimes used or a series of disks.

The vacuum pans used in cane sugar manufacture are much the same as already described in the operation of making beet sugar. They consist of closed vessels in which the juice is boiled *in vacuo*, the removal of atmosphere pressure upon the surface of the liquid permitting it to boil at a lower temperature than in the open air. The grain formed from sirup boiled *in vacuo* is larger and more solid than from sirup evaporated in the open air.

Triple or quadruple effect systems of evaporating apparatus are largely used, since the exhaust steam may thus be utilized.

The pans in the triple effect system may be constructed either side by side or one above the other. The apparatus varies in action as made by different manufacturers. The method of one system is as follows: "In each pan a vacuum is made above the liquid, the vacuum being least in the first jar, greater in the second, and complete in the third. The flow of the liquor through these three pans is continuous, no stop requiring to be made for the discharge. The vapor rising from the boiling liquor in the first pan passes through a 'save all' into the steam drum of the second pan, where it is removed as condense water after giving up latent heat to boil the liquor around it. Similarly, the vapor from the liquor thus set boiling in the second pan passes through a 'save all' into the steam drum of the third pan, where in turn it condenses itself, parting with its latent heat to the liquor now in the third stage of concentration.

"The vapor rising in the third pan, being at so slight a tension as to part with its latent heat only at a temperature too low for it to be further utilized, passes through a 'save all' to a condenser, where it rushes as condense water into the pump. Thus, almost

all the heat supplied to boil the liquor and evaporate its water is used again to repeat the operations to a further extent in the second and third pans."

Rillieux made some improvements in triple action apparatus: "The recipient for discharge steam is provided with an equilibrium valve which regulates the maximum quantity of steam that can be used. The first recipient being the steam generator for the entire apparatus, and heated by the discharge steam of all the engines, is also connected with the discharge water from the coils of the boiling pan through a check valve and pipes. By this means the small excess of steam that escapes with the water assists in heating the first pan, while the combined condense water from the coils and pans passes off through another pipe into a reservoir for the feed pump to the generator."

SUGAR REFINING.

The sugar-refining industry is very important both in America and Europe. Its function is to take the crude raw sugar as it comes from the plantation and produce from it the several grades of commercial sugar.

In most of the beet sugar factories of Europe a commercial grade of sugar is made as the first jet from the centrifugal machines, and it is only the second and third jets that are sent to the refineries. Immense quantities of raw sugar are imported into the United States and England to be worked up in the refineries. Almost the entire importation from Cuba and all of that from the Hawaiian Islands is in the crude condition.

The principal steps in the refining process are (1) melting of the sugar; (2) straining through bag filters; (3) filtering through charcoal; (4) boiling or evaporating the decolorized liquor in vacuum pans; (5) separation of crystallized sugar by centrifugals.

The centrifugals for refining sugar have already been described in the discussion of the beet sugar industry.

A new process of refining sugar in the centrifugals by the use of paraffin has lately been introduced in some European refineries and may perhaps be applied in the United States.

The use of blood in refining sugar has been abandoned, and the purifying is now done with lime.

All the great sugar refineries of France, Russia, and Belgium made exhibits of granulated, loaf, and cube sugar, and of candy sugar, as also of molasses.

HONEY.

France, Italy, and Switzerland had several exhibits of honey. The annual production in Switzerland is valued at $1,600,000 and includes several excellent kinds. The aromatic white honey made in the vale of Chamounix is well known to all Alpine travelers.

Italy produces upwards of 3,300,000 pounds of honey each year, and France about 21,000,000 pounds.

It is estimated that the annual production of honey in North America is 100,000,000 pounds, valued at $15,000,000. There are two species of the honeybee, *Apis mellifica* and *A. ligustica.* The former species is most widely known, and is said to be a native of Asia, whence it has spread over all Europe and America, as well as into Africa and Australia.

Wild honey is collected by primitive people in almost all climes which favor the growth of the necessary flowers. In Ethiopia the natives use for the cure of throat diseases a kind of honey deposited by an insect resembling a mosquito. The honey-making ant of Mexico produces a honey much esteemed by the Mexicans.

IV.—THE COFFEE INDUSTRY.

PRODUCTION AND CONSUMPTION OF COFFEE.

All the coffee producing countries of the world were represented at the Exposition. The exhibits of South America, Central America, and Mexico were very complete in all commercial grades. Orientals had not only exhibits, but booths for the sale of coffee.

The annual coffee crop of the world is 1,430,000,000 pounds, more than half of which is grown in Brazil. The United States consumes one-third of the total crop, or more than the combined consumption of Germany, the United Kingdom, Austria-Hungary, and France.

The imports into the United States since 1879 have been as follows:

	Pounds.		Pounds.
1879	377,848,473	1884	534,785,542
1880	446,850,727	1885	572,599,552
1881	455,189,534	1886	564,707,533
1882	459,922,768	1887	526,109,170
1883	515,878,515	1888	423,645,794

About 50,000,000 pounds of the imports each year are reëxported.

The countries from which the United States received coffee in 1887 were as follows:

	Per cent of total.	Pounds.	Value.	Per pound.
				Cents.
Brazil	60	362,928,304	$36,401,864	10+
Venezuela	11.3	59,463,487	6,770,168	11.4
Dutch East Indies	3.4	18,099,536	2,344,602	12.9
Guatemala	3	15,645,848	2,035,013	13
Mexico	2.7	14,567,005	1,837,450	12.5
Republic of Colombia	2.5	13,595,678	1,437,177	10.6
Costa Rica	1.3	7,211,833	1,061,601	14.7
San Salvador	1.3	6,813,774	809,096	11.8
Haiti	1	5,745,198	709,976	12.3
Netherlands	.9	5,187,837	715,698	13.8
British West Indies	.8	4,551,959	492,586	10.8
Total imports	....	526,109,170	56,347,600	10.7

The extent of the coffee trade in Europe is shown by the following table. These figures do not, however, indicate the actual consumption in the several countries, for in Holland, as elsewhere, much of the importation is afterwards sold to other nations.

Country	1880.		1881.		1882.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Austria-Hungary	69,501,520	$11,481,813	85,345,700	$12,616,186	83,203,340	12,696,026
Belgium	50,061,000	8,747,339	56,900,800	8,414,028	62,053,200	7,394,795
France	127,012,600	18,836,800	142,331,200	18,856,100	140,445,800	16,501,500
Germany	218,240,000	35,879,690	229,020,000	32,225,200	235,620,000	27,534,934
Holland	212,482,600	17,083,794	209,006,800	16,643,202	211,862,000	16,993,544
Italy	23,478,400	4,428,771	31,103,600	5,190,559	31,002,000	4,623,122
Norway	15,767,400	2,362,420	16,726,600	2,139,444	15,384,600	1,686,792
Russia in Europe	18,001,224	4,769,301	15,279,516	4,018,386	18,319,572	4,497,408
Sweden	24,882,000	3,850,356	27,152,400	3,109,068	34,172,600	2,683,752
United Kingdom.......	173,202,512	29,578,509	137,648,336	23,140,253	152,777,408	25,279,465

Country.	1883.		1884.		1885.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Austria-Hungary	74,035,060	$11,193,915	78,051,380	$10,449,092	81,083,417	$10,249,047
Belgium............ ...	62,715,400	7,250,238	44,360,000	5,413,264	57,806,280	6,015,038
France	150,154,400	18,315,700	149,410,800	15,999,700	150,411,800	15,440,000
Germany..............	251,640,000	32,607,904	244,420,000	29,088,122	260,476,650	26,710,264
Holland	283,687,800	22,808,274	229,391,800	18,442,956	225,988,245	18,128,190
Italy	33,750,200	5,034,105	35,824,800	5,028,422	52,029,180	6,831,042
Norway	17,586,800	1,928,260	16,218,400	1,807,928	17,441,580	1,736,248
Russia in Europe.... ..	13,932,000	4,251,650	18,216,000	5,559,255	16,920,000	4,719,120
Sweden	31,238,400	3,196,168	31,176,675	3,561,988	....	....
United Kingdom	157,599,008	23,991,220	127,417,360	18,227,031	115,870,944	11,644,560

France, in 1886, obtained her supply from the following sources:

	Kilograms.		Kilograms
Brazil..	24,900,000	Reunion....................	482,000
Venezuela..................	10,800,000	Guadeloupe	576,000
New Grenada	4,200,000	Egypt......................	700,000
Ecuador	100,000	French Africa..............	2,212,000
English colonies in America.	300,000	English Islands.............	8,900,000
Spanish colonies in America.	5,100,000	Mexico......................	700,000
French Indies	337,000	Guatemala	500,000

The Parisians consume annually about 6,000,000 kilograms of coffee, or an average of 7 pounds for each person per year, about 1 pound less than the consumption per capita in the United States.

HISTORY AND KINDS OF COFFEE.

It is popularly believed that the coffee plant originated in Abys inia, whence it was taken to Austria, then to Java, and to Europe,

whence it was transferred to the West Indies and Brazil. It is now widely distributed throughout the intertropical belt. Brazil, as already shown, produces one-half the entire crop of the world. Venezuela is next in importance.

Most of the other countries of South America, also Central America, Mexico and the West Indies are large coffee-growers.

MOCHA COFFEE.

Mocha coffee is considered the best of all. Genuine Mocha is grown in Arabia where coffee culture has been carried on for more than four centuries, and for two centuries the Arabians furnished the coffee supply for the world. Now, however, a comparatively small amount of Arabian coffee enters into consumption, not more than 4,000 tons per year being exported, half of which goes to France. The Mocha seed has been planted in Brazil and other countries, but with change in place there seems to be a change in the character of the plant and berry. The Mocha berry is round, and when fresh roasted has a rich aroma. The large beans are preferred in Europe, while Americans prefer the small ones.

JAVA COFFEE.

Java coffee ranks next to Mocha in price, and is by many preferred to the latter. Though deriving its name from the island of Java, not all the coffee of that name grows there. Most of the Java coffee brought to the United States comes from Sumatra. The annual crop at Java and Sumatra, until a few years ago, was 140,000,000 pounds. Since 1883 there has been a decrease. The crop of 1886 was 118,225,163 pounds, while that of 1887 was only 45,586,681, the poorest year on record.*

Most of the Java coffee is grown on plantations belonging to the Government, and the planters sell their crops to the Government agents at a fixed price. The coffee is sent to Holland to be sold at periodical sales in Amsterdam and Rotterdam. There are two principal grades of Government Java coffee, the first a fine color and not broken ; the second dark beans, or those of inferior shade, or broken. A third grade cracked (W 1 B), and some other kinds are also grown in small quantities at Java.

The coffee credited in the imports as coming from Dutch East Indies and Holland is Java coffee.

COFFEE OF CEYLON AND INDIA.

Ceylon grows 43,000,000 pounds of coffee each year. About 200,000 pounds is native coffee, and the rest plantation Ceylon coffee, known in the United States as Pea-Berry, No. 1, 2, 3, and Triage, terms

*The principal cause of the decrease is the destruction of the trees by *Hemideia vastatrix*, somewhat similar to mildew on vines.

derived from the methods of screening the berries into different sizes. The bean is heavy and solid, and varies in color from white to yellow.

The crop of coffee in Britsh India now averages 36,000,000 pounds.

AFRICAN COFFEE.

Liberia grows a coffee that finds considerable favor, though the crop is not a great one. The beans are sometimes an inch or more in length, while the Java or Mocha bean seldom exceed a half inch.

Along the east coast of Africa, and on Madagascar, Reunion, Mauritius, and some other islands, coffee culture is assuming some importance.

BRAZILIAN COFFEE.

The culture of coffee is of immense importance in Brazil. The exports for the years ended June 30, 1884 to 1886, were as follows:

Years.	Kilos.	Francs.
1883-'84	318,978,000	325,200,000
1884-'85	374,292,000	381,080,000
1885-'86	326,186,000	311,980,000

The coffee plant was introduced into the French colonies of South America from the Antilles. It soon passed to Cayenne, and was imported thence into Para about 1727. Its culture had greatly developed in the north of Brazil in 1761, and a little later the culture of this plant began at Rio Janeiro, but it was not until the present century that the coffee industry became of real importance in Brazil. In 1820 the very poor crop of sugar cane led planters to pay particular attention to coffee culture. In 1840 improved methods of preparation of coffee supplanted the primitive methods employed up to that time. In 1862 the neighboring province of San Parlo, and later Minas and Espinito engaged extensively in the culture of this plant. These four provinces now form the central zone of the coffee industry. Another zone of much less importance is constituted principally by the provinces of Bahia and Ceara.

Brazilian coffee varies greatly in size and in color, so that nearly all the staple commercial coffees of the world may be furnished. Rio coffee, marketed in the United States, is either light or dark green, with some Golden Rio of a yellow hue. To meet the requirements of the markets for certain shades, the berries are sometimes artificially colored.

The coffee is divided into six principal grades, known as fancy, prime, good, fair, ordinary, and common, and these are subdivided into a dozen more. The standard for each grade varies according to the market. In a season of scarcity, the poorer grades become good ones, and in abundant seasons the reverse is the case.

COFFEE OF VENEZUELA AND COLOMBIA.

Venezuela and the United States of Colombia produce annually about 120,000,000 pounds of coffee, commercially known as Maracaibo, Laguayra, or Porto Cabello. Cucuta, the finest grade of Maracaibo coffee, is grown in the United States of Colombia. Other grades of Maracaibo are Merida, Tovar, Bocono, and Trujillo. The best qualities are often sold for Java coffee.

Laguayra coffee is grown in Venezuela, near Caracas. Much of the crop is sent to the United States under the name of Caracas or Trillados coffee. Angostura coffee is raised in Venezuela.

COFFEE OF CENTRAL AMERICA AND MEXICO.

Costa Rica, Guatemala, Nicaragua, and other States of Central America grow annually about 125,000,000 pounds of coffee. The Costa Rica bean when roasted has a heavier body than Java or Maracaibo, and has a fine flavor that ranks with the best of Java or Maracaibo coffee. The "male berry" is often sold for Mocha. Guatemala coffee, also, is very highly esteemed; it varies from a dark to a bluish green. The Salvador bean has a very sweet smell and is of a yellowish color.

Mexico exhibited some coffee grown in Vera Cruz, Tehuantepec, Tuxpan, and other districts. Vera Cruz is the headquarters of the industry, which is increasing in importance. The annual crop is about 16,000,000 pounds.

WEST INDIA COFFEE.

The West Indies formerly produced much more coffee than at present. Jamaica grows a berry known as the "Blue Mountain" which is much esteemed, about 8,000,000 pounds being annually exported.

One hundred years ago Haiti produced about 80,000,000 pounds of coffee, but the yield is now much less; in 1886 the exports were 58,075,733 pounds. The crop in San Domingo in 1887 was 7,652,343 pounds.

Porto Rico coffee is much in favor in Spain and in Cuba. In 1884 the exports were 66,873,106 pounds, and in 1885 only 41,892,610. In 1886 the exports were as follows:

	Pounds.
Austria	601,800
Cuba	12,218,844
Spanish possessions	1,045,024
England	361,922
France	7,742,690
Germany	3,391,920
Italy	1,594,772
Spain	5,187,308
United States	1,478,892
Total	33,623,172

The island of Trinidad grows about 900,000 pounds of coffee a year, and in Cuba the crop is about 2,000,000 pounds.

PREPARATION OF COFFEE FOR MARKET—ROASTING.

The preparation of coffee for market varies greatly in different countries. The first operation is to remove the hull of the berry so as to release the two beans. The hulling is done either when the berry is green or after drying, the work being performed with machines. When divested of its pulp the berry is called "parchment coffee," being inclosed in a thin cover, and the inner bean is also covered with a filament called the silver skin. A machine called a peeler is used to remove these two husks. The beans are then winnowed and are passed through a sizing machine to separate them into commercial sizes or grades.

In Brazil, both the wet and the dry methods of hulling are employed. By the former, the berry just as gathered is put in a tank of water, and then into the *despolpador*, which partly removes the pulp. It is hen pounded in the *batidor*, which completes the hulling. After drying a few days, the beans are baked for shipment under the name of "washed" coffee.

Most of the Brazilian coffee is prepared by the dry method; the newly gathered berries washed in a tank and sun-dried for about three weeks, care being taken to protect them from the rain. In drying, the skin turns black and forms a brittle hull, and the white, sweet pulp almost entirely disappears, leaving on the kernel a thin covering mentioned above as the silver skin. A common theory is that the pulp is absorbed into the bean and is the cause of the best flavor of coffee. Steam-drying machines have been invented but are not wholly satisfactory.

Among the poorer coffee planters machinery is not employed, but the berry is dried in the sun and the pulp removed by pounding in wooden mortars.

Coffee roasting is a very important operation, for the flavor depends in a great measure upon the proper performance of this process.

COFFEE ROASTING.

Numerous roasting machines were shown at the Exposition. They differed little from one another except in manner of handling. There are two shapes, globular and cylindrical; the former are largely used in Paris. From 30 to 45 minutes or more are required to roast the coffee, according to the kind of bean. Three-quarters of an hour may be considered the average time for roasting. There is a loss in weight from 14 to 18 per cent, the average being about 15½ per cent. Sugar is sometimes put in the roaster just before the operation is finished, and makes the beans black besides imparting some flavor.

Different kinds of coffee are very often blended to produce desired

flavors. The Parisians sometimes blend half a dozen varieties and are very expert at it.

Among the coffee roasters exhibited were some portable ones for roasting from 1 to 20 pounds, and that sell at $2 to $5 each (Fig. 13); also some larger ones holding from 6 to 40 pounds, and selling at $9 to $30 each (Fig. 14).

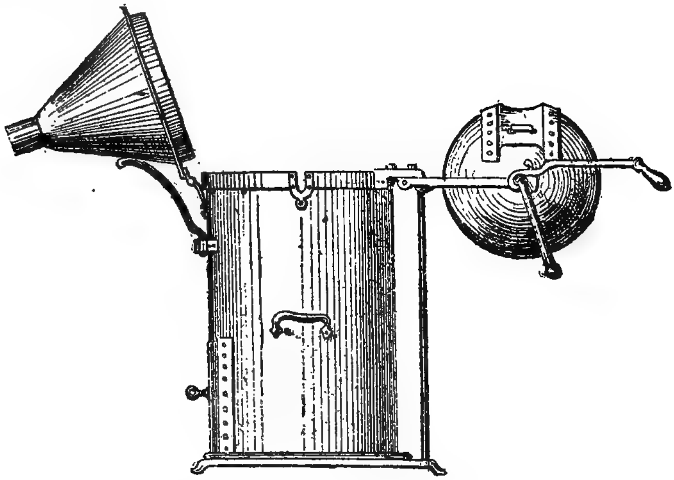


FIG. 13.—Lauzanne's coffee roaster.

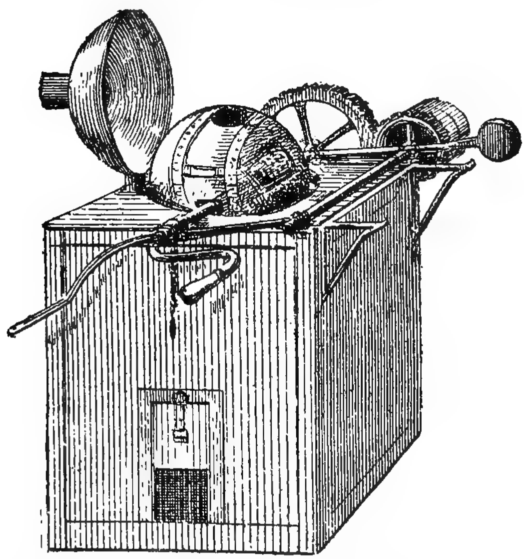


FIG. 14.—Lauzanne's coffee roaster.

A coffee roaster that attracted much attention was exhibited by Ferro Cardozo, of Paris, having a capacity of 1,000 pounds of coffee, combining the application of steam, a vacuum, and condensation. It is heated by steam and all the smoke produced by the roasting operation is condensed in cold water. This apparatus (Fig. 15) occupies only about 53 square feet, and is sold at $2,000.

PREPARATION OF COFFEE FOR THE TABLE.

There were several exhibits of coffee extract, essence of coffee, granulated coffee coated with gelatined flavoring, powdered coffee, etc. In special cases these preparations serve their purpose, but it seems to be the general opinion among coffee drinkers that the whole bean ground at home can hardly be improved upon. The natives of Java and other coffee countries make an infusion from the leaves of the coffee tree, preferring this to drink made with the bean.

In preparing coffee for the table, opinions differ greatly as to the best method. Perhaps there is no best method, for what suits one person may be distasteful to another. There are, however, some special processes that are superior to others. Mr. F. B. Thurber,* in his valuable book on coffee, discusses in detail the methods of coffee-making in all countries, and I can not do better than refer the reader to that extremely interesting work.

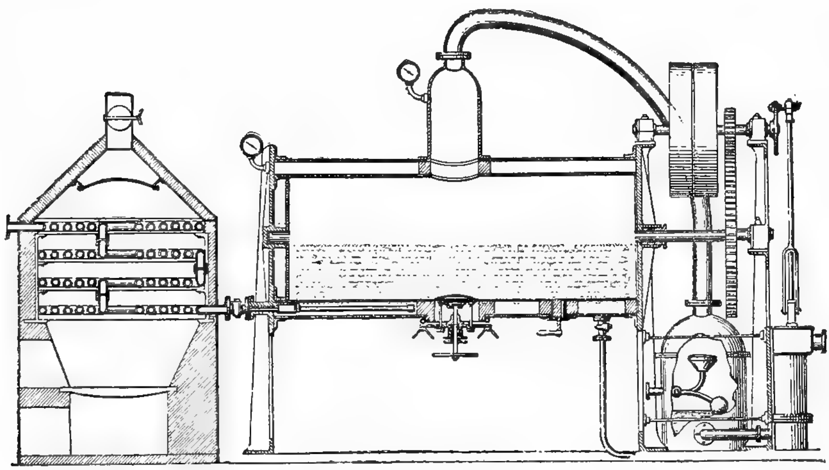


FIG. 15.—Cardozo roaster.

The Thurber recipe for making the beverage is to "grind" moderately fine a large cup or small bowl of coffee; break into it one egg with shell; mix well, adding enough cold water to thoroughly wet the grounds; upon this pour 1 pint of boiling water; let it boil slowly for ten or fifteen minutes, according to the variety of coffee used and the fineness to which it is ground. Let it stand three minutes to settle, then pour through a fine wire sieve into a warm coffeepot; this will make enough for four persons. At table, first put the sugar into the cup, then fill half full of boiling milk, add your coffee and you have a delicious beverage.

In Turkey powdered coffee is measured into a tiny coffeepot, water

*Coffee from plantation to cup; Francis B. Thurber; Fourteenth edition. New York, 1887, pp. 416, 8vo.

poured in, and then it is set upon live coals until it heats up to the boiling point. Without straining or otherwise settling the grounds, the coffee is served in tiny cups. Though thick and muddy, the coffee tastes well. The Turks use no milk in their coffee.

French coffee is of world-wide renown. To make a cup of café noir, they grind two tablespoonfuls of coffee, pack it solidly in a coffeepot of the ordinary French filtering pattern, then pour on boiling water, passing it twice or three times through the coffeepot. Café au lait is made the same way, milk being added as served to suit the taste, usually about three parts of milk to one of coffee. French families frequently practice economy by pouring hot water over the grounds left in the coffeepot, and bottle the weak coffee then made, to be used instead of water in making coffee for the next meal. In some of the well-known cafés, Mocha, Java, Martinique, Guadeloupe, or East India coffees are used together in carefully ascertained proportions. A small glass of brandy or liqueur is commonly taken, either in or with black coffee.

Vienna coffee is prepared as follows:

At the large cafés or hotels, to make 6 quarts, 1 pound 6 ounces of coffee are used. Within a very heavy cylinder or urn that is securely pinned to the floor or table, there is fitted a common sieve, a piece of cord or rope surrounding the sieve, making it fit tightly. Over the sieve there is placed a piece of canton flannel, fastened down by means of an iron ring that fits into the rim which holds the sieve. Attached to the sieve is an iron frame, with a hook at the top. The sieve is pressed to the bottom of the cylinder, the coffee placed upon the flannel, and boiling hot water poured upon it. This receptacle is then closed and covered, and allowed to stand six minutes. A screw fitted into an iron frame is then hooked onto the frame holding the sieve, which is then forced towards the mouth of the urn, the person forcing the infusion through the canton flannel. The coffee is then ready to be served with hot milk or whipped cream. For the use of families, a coffeepot of somewhat novel character is employed. This is more complicated than the simple contrivance described above. The water is boiled by means of an alcohol lamp underneath the pot. When the water boils, the steam passes through a tube, and through the finely ground coffee which has been placed loose in the top and protected by several strainers. A glass top enables the operator to see when the coffee is ready for use, and when finished, the glass cover is removed and a metallic one put in its place. This process secures a perfect infusion of the coffee without loss of aroma, and it has made Vienna coffee deservedly popular.*

CHICORY AS A SUBSTITUTE FOR COFFEE.

Chicory is much used in France and elsewhere in Europe as a cheap substitute, or to mix with coffee.

France grows annually 5,567,100 kilograms of dried chicory; Belgium, 258,675,450 kilograms green; Germany, 250,000,000 kilograms green, and Holland 27,500,000 kilograms. There is a loss of 65 to 70 per cent in weight in drying the chicory, and a further loss in grinding into powders, in which form it is mostly used.

*Thurber.

It is estimated that about one-third of the 6,000,000 kilograms of coffee used in Paris is intentionally mixed with chicory, in the proportion of one-fourth chicory to three-fourths coffee. The annual consumption of powdered chicory, therefore, is about 500,000 kilograms.

V.—THE TEA INDUSTRY.

STATISTICS OF TEA TRADE.

The annual production of tea in the world is 500,000,000 pounds, or one-third less than the crop of coffee. One pound of tea makes 6 gallons of beverage, while a pound of coffee makes only 2 gallons.

The English-speaking people and the Russians are great tea-drinkers. England and her colonies consume nearly half the total crop of the world. The United States and Russia each consume about one-sixth of the crop.

England buys most of her tea from Ceylon and India. In 1889 the imports were 127,160,409 pounds of India and Ceylon tea, 88,848,574 pounds from China, and 5,593,677 pounds from other countries, making a total of 221,602,660 pounds, of which 185,621,800 pounds were for home consumption.

The people of the United States spend each year about $33,000,000 for tea, estimated at the retail price. In 1888 the imports were 84,627,870 pounds, received from the following countries:

Country.	Quantity.	Value.
	Pounds.	
China	43,043,651	$7,002,875
Japan	37,627,560	5,595,054
England	3,333,023	653,048
Hongkong	209,658	30,465
Canada and provinces	186,407	37,255
British East Indies	99,647	21,495
British Columbia	70,712	8,570
Nova Scotia, New Brunswick, and Prince Edward Island	33,489	6,431
Scotland	12,392	2,200
Germany	9,992	2,665
Ireland	964	507
Russia	180	69
Philippine Islands	100	20
Argentine Republic	60	10
Belgium	35	21
Total	84,627,870	13,360,685
Year ending June 30,		
1887	89,831,221	16,771,802
1886	81,887,998	16,020,383
1885	72,104,956	14,047,583

The tea received from England and Canada was made up in part of India tea, and we also received some direct from India, but it will be seen that nearly all our tea is either Chinese or Japanese. The small amount coming from the Argentine Republic may have been Maté or Paraguay tea, mentioned elsewhere in this report.

China, Japan, and India, including Ceylon, are three great tea-producing countries. In recent years the tea industry has been very greatly developed in India, and is contesting the market of the world with China. Already more than half of England's purchases of tea come from India.

The production of tea in Japan, in 1885, was 45,366,556 pounds. These are the official statistics, though the statement is made that the exports are nearly equal to this amount, and that full returns are not given of the immense quantities consumed in the country.

In Java tea culture is carried on exclusively by Europeans. Chinese and Assam teas are the kind principally grown. Ten years ago scarcely any green tea was prepared, but now all the commercial grades of black and green are made.

The annual tea harvests from 1883 to 1887 were as follows:

	Kilograms.
1883	2,336,643
1884	2,494,532
1885	2,400,085
1886	3,351,626
1787	2,052,634

Some tea is also grown in Australia, and experiments are constantly going on toward its introduction in other countries.

Special efforts were made at the Exposition to create a favorable opinion of India tea. At the Ceylon pavilion this tea was daily served to many thousands of visitors from all over the world, and there is little doubt that the demand for India tea will greatly increase. Already, indeed, the production is unequal to the demand.

KINDS OF TEA AND ITS PREPARATION.

There is but one tea plant, *Thea sinensis*, though this is varied considerably by cultivation. Green tea and black tea differ only in the method of drying. The original green color is retained by the rapidity of the drying process, though sometimes it is artificially produced by the addition of Prussia blue mixed with gypsum and indigo.

In Japan the first three leaves on each stem of the tea plant are picked, while in India six leaves are taken. Most of the Japanese product is prepared as green tea. The leaves are steamed for about a minute, then spread on mats to cool. They are then dried in paper trays over a smothered fire for an hour, during which time they are kept in motion by rolling or stirring them until they have assumed

the requisite twist or curl. They are then cooled and again dried, the operation being repeated five or six times, and each drying gives the leaves a darker shade. The dried leaves are next winnowed and screened to remove the dust, and all stems and uncurled or broken leaves are picked out by hand.

Tea which is to be exported is further cured by more careful drying, sorting, and sifting. Certain flavors are made by blending teas from several provinces.

In China, the best quality of tea is submitted to careful treatment. The leaves are partially dried, either in the sun or shade, and are then further dried in sieves over charcoal fires, cooled, tossed, roasted in thin iron vessels, again cooled and further cured in a drying tube or cylindrical, paper-lined basket. Cheap grades of tea are simply dried in the sun and rolled by means of a furrowed stone, and the balls of leaves thus made are picked apart and again sun dried, the operation being several times repeated.

From the leaf bud the Chinese made Pekoe tea, called by the French *fleur de the.*

Bohea tea is made from full-grown leaves left after the regular harvest, and is the lowest grade.

In the preparation of green tea the leaves are first steamed, so as to retain their color, and care is taken in the drying operation.

The principal kinds of black tea are Oolong, Congou, Flowery, Pekoe, Souchong; and the green teas are Hyson, Twankay, Fine Imperial, Scented Caper, and Gunpowder. A given bulk of Gunpowder is more than three times heavier than the same bulk of Oolong, and twice as heavy as Flowery Pekoe.

The Flowery Pekoe and other teas are generally scented with jasmine blossoms during the drying process. In China the first quality of tea is made from the tender leaves plucked at the beginning of May; the second quality is gathered in June, and the third in July. A small quantity of teon-tcha, or first grade of tea, has three or four times the strength of the other qualities.

Fuchau and Hankeoo are the two great tea markets of China. The exports from Hankeoo have the generic name of Congou tea. The best black teas of Fokien are designated as *Congou* and *Souchong,* and their average value in China is about 38 cents a pound, while inferior grades of the same kinds sell as low as 9 cents a pound. Fine qualities of teas are sent overland to Moscow and are known as Caravan tea.

BRICK TEA AND TEA TABLETS.

Great quantities of so-called "brick tea" is made in China for sale in Russia and Central Asia. There are three kinds: Bricks of black tea sent to Siberia; green tea sought for by the nomad tribes of Asia; and tablets of first quality tea sent to Russia.

The black tea bricks are made from leaves of the second and third harvesting, which are generally overmature, with the addition of light leaves and refuse of the better leaves, and stock left over from previous crops.

About 2¼ pounds of this material is steamed for some seconds in a linen bag and is put into a wooden mold, lined with tea dust, and subjected to heavy pressure. The tea which is very hard when taken from the mold is then dried for about a fortnight, and is then wrapped in paper for shipment.

The green-tea bricks are made in the same manner as the last, but the bricks are smaller than the black-tea bricks.

The bricks of tea have become such a common article of traffic that they are used as money in nearly all commercial transactions in Central Asia.

The Mongols divide a brick into 30 equal parts, and each part is called a *cha ra*. A sheep is valued at 120 *cha ra*, or 4 bricks.

The tea tablets are made from the siftings of good quality Congou tea, compressed by hydraulic machines. Each tablet is divided into eight portions like a cake of chocolate, and weighs about a quarter of a pound.

Tea will keep in this condition for many years without losing its aroma.

MATÉ OR PARAGUAY TEA, AND OTHER SUBSTITUTES.

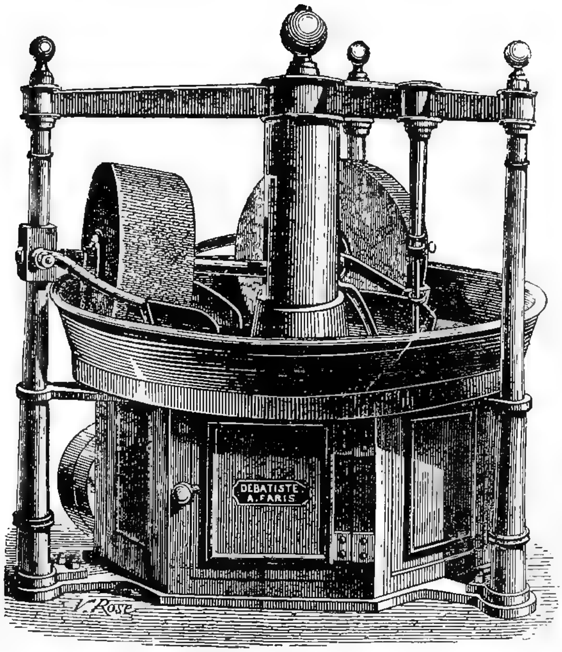
Nearly thirty other plants besides the tea plant proper are in various countries used in the same manner as the genuine tea. In South America Paraguay tea or maté is an important article of commerce. The *yerba maté* is the product of the *Ilex Paraguayensis*, a tree much resembling the orange, great forests of which grow in Paraguay and in Brazil. Tea made from maté is the national drink of South America. Besides the home consumption, Paraguay produces annually a surplus of 13,000,000 pounds of the maté for exportation, valued at $800,000, and the product of Brazil is estimated at 66,000,000 pounds, about 15,000,000 pounds of which were exported in 1886.

VI.—THE COCOA INDUSTRY.

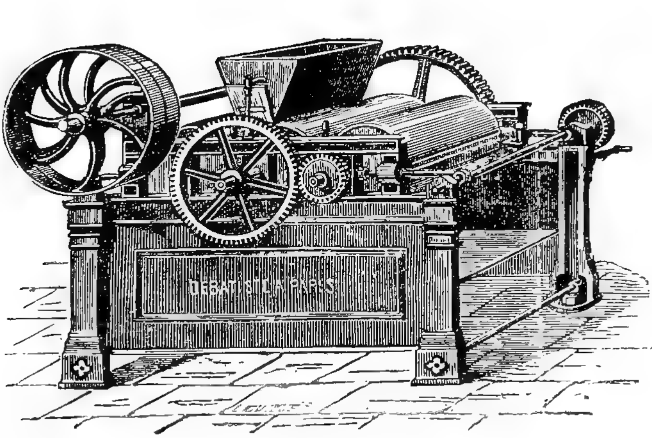
COCOA AND CHOCOLATE.

All the varieties of cocoa and its preparations were well represented at the Exposition. The principal producing countries are Mexico, Central and South America, and the West Indies.

The species mostly cultivated is *Theobroma cacao*. Other species of *Theobroma* are *T. angustifolia*, *T. bicolor*, *T. Glanca*, *T. Gnyanensis*, *T. microcarpa*, *T. ovalifolia*, *T. speciosa*, and *T. sylvestris*.



1. CHOCOLATE GRINDER AND MIXER.



2. CHOCOLATE ROLLER MILL.

The *T. cacao* is known commercially under the name of the country producing it, except in the case of Venezuela, the cocoa from there being sold as Masacaibo or Caracas. Cocoa planters distinguish several varieties of *T. cacao*, the best variety being the "Criollo" of Venezuela. The pods of the "Criollo" are small, but the beans are thick, short, and almost globular, pale crimson in color, and of slightly bitter but agreeable flavor, soft and oily.

A second variety is the "Forasters," and a third the "Amelonado," which are drier and more bitter than the "Criollo." All the varieties of *T. cacao*, except Criollo, are known collectively as "Trinidad."

The several descriptions of cocoa have about the following order of merit: Soconuzco (Mexico), and Esmeralda (Ecuador); Caracas and Puerto Cabello (Venezuela); Trinitario (Trinidad); Magdalena and Carthagena (New Granada); Para; Bahia.

The fruit is a pod 6 to 10 inches long and 3 to 5 inches broad, containing from 20 to 50 seeds imbedded in a soft, pink, acid pulp.

In preparing the seeds for market they are first removed from the pods, the acrid juice drained off, and are then inclosed in a "sweating box," or placed in the ground and covered with clay, and allowed to undergo partial fermentation, by which the color and flavor are developed. They are then carefully dried in the sun.

The seeds contain, besides starch, cellulose, etc., about 50 per cent of fat, "cocoa butter," and a peculiar principle called theobromin, nearly identical with the active principle of tea and coffee.

To prepare the seeds for use, they are roasted, crushed, and winnowed to remove the husks. The husks are known in commerce as "shells"; the crushed seeds are called "cocoa-nibs"; cocoa-nibs ground to a paste makes "flaked cocoa"; flaked cocoa mixed with sugar and aromatized is "chocolate." The ordinary "cocoa" of commerce consists of the powdered seeds deprived of a portion of their oil by pressure between heated plates.

The various forms of cacao are much used in decoction as a beverage, less stimulating but more nutritious than tea or coffee. The fat, cocoa butter, is used for pharmaceutical purposes.

Brazil is largely interested in cocoa culture. Cocoa trees are extremely abundant in all the valley of the Amazon and in the valleys of the Negro, Gavary, and Sepura, where it grows wild and forms an important food for the Indians. The Province of Para is the principal center of the industry, then the Amazon Province. The Port of Belem in 1887 exported 4,250,000 kilograms.

There were some very fine exhibits of chocolate and chocolate-makers' machinery. In the French section, Menier and Lombast each had very interesting collections of products, and daily showed the operation of chocolate-making with the most improved machinery. Other establishments, as George Borman, of St. Petersburg,

Henry Maillard, of New York, Van Houton, of Holland, and many more from Spain and other countries, had exhibits worthy of much praise.

Sixty years ago France produced about 400,000 pounds of chocolate a year, and it was sold by pharmacists and dealers in fine confectionery. The production of a single one of the great French manufacturers is now 330,000,000 pounds of chocolate, worth $12,000,000. The importation of cocoa in France, in 1888, was 24,689,203 kilograms, almost all of which was used in making chocolate.

Chocolate is a mixture of cocoa and sugar ground together and flavored with vanilla, cinnamon, and other condiments. Cane sugar is more generally employed than beet sugar in chocolate making.

The average price of chocolate in France is 30 to 35 cents a pound, and is generally sold in tablets of one-half or one-fourth of a pound, though it is also made in small pieces in fancy forms.

The cocoa as imported is mixed with more or less dirt and other impurities that must be separated, and the beans are screened according to size. After being roasted and freed from the dry, thin husks, the beans are crushed under stone rollers and made into an unctuous paste which is mixed with the necessary proportion of sugar. The mass is again thoroughly ground, and it is then passed between several sets of rollers. The paste is next heated in stoves and mixed again in rollers or crushers, and is then put in molds. The molding is done in cool chambers, a low temperature being necessary to the proper manipulation of the material. Systems of ventilating the rollers used in grinding have also been devised, as cool air is found to facilitate the operation.

A preparation of chocolate and milk was exhibited in powder and in tablets by Federico Bauder, of Paris.

VII.—SPICES AND CONDIMENTS; LIQUEURS.

SPICES AND CONDIMENTS.

PEPPER.

The ordinary commercial pepper is the fruit of the pepper plant, *Piper nigrum*, that grows both in the West Indies and in several Oriental countries.

Sumatra is the principal center of the industry in the East. The distinction between black pepper and white pepper is due to the method of preparation. The former is the whole berry carefully dried, while the latter is the ripe berry soaked in water or otherwise treated to remove the outer husk, which contains some of the bitter properties of the fruit.

The French eat great quantities of pepper, as in fact of all high

seasonings. In 1887 the imports of pepper into France aggregated 5,091,284 pounds, valued at $830,000. Americans seem to prefer pepper ground to powder, while Europeans, especially the French, consume more of coarse pepper.

In 1888 the United States imported 12,949,598 pounds of pepper, worth $1,823,239.

CAYENNE.

Red pepper or cayenne is the crushed pod of the species of *Capsicum*, and is not properly a pepper. It grows on the east coast of Africa, where it is known as "Zanzibar pepper," and in tropical America.

NUTMEGS AND MACE.

The French Indian colonies exhibited nutmegs and mace. The latter is prepared from the mantle or one of the outer coverings of the nutmeg. This spice is valued according to the size of the fruit; those weighing four to the ounce, an inch long, and eight-tenths of an inch broad are the highest price.

The United States imported 1,248,096 pounds of nutmegs in 1888, valued at $603,556.

CINNAMON AND CASSIA.

Ceylon and the French colonies in the East exhibited specimens of the cinnamon and cassia bark. The Ceylon cinnamon is from one-eighth to one-sixteenth of an inch thick, the outer and inner layers of the bark being removed. Cassia is thicker than the Ceylon cinnamon, and generally shows the outer corky bark.

In 1886 the imports of cinnamon and cassia into the United States were as follows:

	Pounds.	Value.
Cassia buds	238,031	$15,062
Cassia, ground	1,851,100	115,659
Cinnamon and chips	78,927	11,485
	2,168,058	142,206

GINGER.

Commercial ginger is the dried root of a plant growing in warm eastern countries, in the West Indies, and generally in tropical regions.

Jamaica ginger is one of the best varieties and is carefully prepared by scraping and drying the ginger roots. The kinds that come from India are usually unscraped.

In 1886, the United States imported 4,277,110 pounds of ginger root, valued at $220,415.

Preserved ginger, a fine quality of which is made in China, is prepared by scraping the root, and after a careful washing it is boiled in kettles for about 24 hours, and then soaked for about the same time in salt water. The pieces are then punctured, washed in fresh water, dried in the sun, and boiled with an equal weight of sugar for 12 hours. It is put in earthern jars and the sirup added, and, after remaining in the jars for several days or weeks, is again boiled for a short time and is ready for final packing.

CLOVES.

Cloves were exhibited by several Oriental countries and by the French colonies on the east coast of Africa. This spice is the flower bud of an evergreen tree, *Eugenia caryophyllate.* Penany and Sumatra cloves are considered the best in the market.

PIMENTO OR ALLSPICE.

The spice known as pimènto or allspice, the fruit of *Pimento officinalis,* was exhibited by some of the West India colonies.

MUSTARD.

In the French section of the Exposition, there were several exhibits of both ground and whole mustard, and of apparatus used in the preparation of the ground, bottled product. It is estimated that Parisians alone consume annually 220,000 pounds of fine mustard and 880,000 pounds of the ordinary mustard.

BURNT ONIONS AND CARROTS.

In Paris burnt onions and carrots were formerly used to color soups, but they have been generally replaced by caramel or burnt sugar and various compounds put up in little balls.

VANILLA.

Vanilla, so popular a household flavor, came originally from Mexico, and, as might be expected, that country had a good exhibit of the several merchantable grades of the vanilla bean and preparations made from it. Java, the French colonies in the east, and India also exhibited excellent specimens of this flavoring.

Vanilla is largely used in France and Spain in the preparation of chocolate. In 1887 France imported 73,418 pounds of vanilla, valued at $300,000.

The vanilla exhibited from the Island of Bourbon was of dark color and of strong though not delicate perfume. The vanillon, or wild vanilla, is used chiefly in the manufacture of perfumery, the odor resembling heliotrope.

CHINESE SOY.

"Soy," which is much used as a basis for sauces, is made in China from a white bean called "*pak-toh.*" The beans are boiled, salted, and left to ferment, and are then crushed up with a species of olive, boiled again, and strained, and the liquid is thickened with molasses.

LIQUEURS.

The exhibit of liqueurs was very complete, including hundreds of varieties of compounds and flavorings. Alcohol, sugar, and essence form the basis of all liqueurs, and upon the purity of these ingredients depends the quality of the product.

Alcohol distilled from beets, from grain, or from wine is used in this industry, though the best product results from wine alcohol. Besides beet and cane sugar, glucose is also used.

The essences used include in great part aromatic plants, such as anis, absinthe, coriander, bayberry, and vanilla, from which the essential oils are extracted, either by distillation, or by pressure, or by maceration.

Saffron, cochinille, indigo, Prussian blue, and certain woods are used for coloring.

The French colonies and South American countries sent to the Exposition a large variety of compounds, such as extracts of cocoa, tea, pineapple, magnolia, orange, etc.

Orange flavoring is much liked by the French. There were numerous exhibits of orange extract from various countries. It is made by steeping the flowers in distilled water. It is estimated that the confectionery and pastry shops of Paris use annually 44,000 gallons of this flavor.

CLASS 73.—FERMENTED DRINKS.

By CHARLES McK. LEOSER,

Member of international jury, class 73.

CLASS 73.—FERMENTED DRINKS.

By CHARLES McK. LEOSER.

I.—REVIEW OF EXHIBITS BY COUNTRIES.

The International Exposition of 1889 at Paris showed that great progress and much improvement in the growth and manufacture of wine had been made in various parts of the world, but it showed also that what had before been true, that the palm of incontestable superiority belonged to the noble wines of the Médoc, the Côte d'Or, and Champagne, still remained true, and it is probable that for a great many years it will continue true.

It is to be regretted that the only wines grown in the world that are worthy of comparison with those just mentioned, the great growths of the Rhine, were not seen at the Exposition, but sad to say there were no German wines there.

The other wine-growing countries of the world were well represented, and amid the dazzling display of the Latin races the insignificant show of our country was pitiable.

The exhibitors in class 73 were divided among the various nationalities as follows:

France	2,600	Cuba	2
Algiers	1,636	Cape of Good Hope	3
Gaboon Congo	1	Chili	84
Guadeloupe	25	Denmark	6
Inde Française	4	Dominican Republic	13
Martinique	31	Egypt	2
Mayotte	2	Ecuador	7
New Caledonia	8	Spain	619
Réunion Island	14	United States	57
Senegal	1	Great Britain	25
Tahiti	2	Greece	83
Annam Tonquin	1	Guatemala	8
St. Pierre de Miquelon	2	Haiti	2
Tunis	26	Hawaii	1
Argentine Republic	113	Honduras	14
Austria-Hungary	28	Italy	45
Belgium	91	Japan	32
Bolivia	4	Luxembourg	1
Brazil	24	Monaco	4

Mexico	88	Russia	77
Norway	12	Finland	4
Nicaragua	11	San Marino	10
Paraguay	5	Salvador	8
Peru	2	Servia	48
Netherlands	21	South African Republic	1
Persia	2	Sweden	3
Portugal	520	Switzerland	82
Portuguese colonies	13	Terre Neuve	2
Philippine Islands	2	Uruguay	7
Puerto Rico	12	Venezuela	8
Roumania	63		

Making a total from France and her colonies of 4,352 and from other countries of 2,275, a grand total in the class of 6,627.

At the exposition in 1878 there were 5,666 exhibitors in the class.

The French exhibit in Class 73 was made up by 2,600 exhibitors, of whom 2,262 appeared merely as component parts of departmental associations, or direct syndicates, like those of the Charente-Inférieure, Champagne, Côte d'Or, etc. The committee in making the awards treated these organizations, in some cases, as individuals, and awarded prizes accordingly.

The exhibit gave, of course, a perfect view of all the productions of the country in the class, including wine, brandy, spirits, cordials, rum, beer, and cider. It is perfectly safe to say that in number, quality, and arrangement the exhibition of the French in this class was incomparably superior to anything else of the kind the world has ever seen. The syndicate of the champagne trade arranged a series of life-size figures, showing the whole process of the manufacture of champagne, together with maps of the district, models of culture methods, etc., so that without going out of the apartment the visitor was enabled to get a very clear idea of the progress of a glass of champagne from the vine to the table. Naturally, the wines and spirits shown from Bordeaux, the Côte d'Or, Champagne, and the Charentes were the best, each in its kind, that the world produces, and it only remained for the jury, consisting of 45 Frenchmen and 38 foreigners to determine what they should give themselves. The record of the awards will stand as an everlasting monument to their modesty.

The 1,636 exhibits of Algiers were principally made up of red and white wine, of which much the larger proportion was red.

In addition to these, the Algerians showed some brandy distilled from wine and some from marc, vermouth and muscat, cider and brandy of figs, absinthe, Curaçao and other liqueurs, and beer.

The wine industry of Algiers has taken on a very rapid extension of recent years; the production of the colony in 1888 was 71,280,000 gallons, which is marketed at about 12 cents a gallon.

The present acreage in vineyards is about 250,000 acres, which

gives a yield of 280 gallons per acre. The acreage is increasing at the rate of about 25,000 acres per annum.

The exports of wine from the three departments of Oran, Constantine, and Algiers were, in 1879, 158,400 gallons, and in 1888, 29,600,000 gallons. These figures are furnished by the departments.

The usual cryptogamic diseases are known in all the departments, but little trouble has been experienced from insects, although the phylloxera made its appearance in certain spots in 1885. The general exemption from its ravages is to be credited to the wise and timely steps taken by the government of the colony.

After some early experiments with Alicante, Carignan, and other varieties, the Algerian growers took up the Bouschet, which was very popular for a time, but it disappointed them in the end in both color and alcohol, and they are now turning to Cabernet-Sauvignon, Cots, Malbec, Pinot, Aramon, Syrha, Verdot, Sémillon, La Folle, Blanche, etc., all of which are said to be doing very well.

The lonely exhibit of the Congo Gaboon Colony consisted of brandy distilled from the juice of the mango.

Guadeloupe exposed twenty-five samples of rum, vanilla spirits, orange wine, a spirit distilled from the guava, and bay rum.

The manufacture of sugar and rum is the principal industry of Guadeloupe. The product of 1886 was 127,765,937 pounds of sugar, 11,695,200 pounds of molasses, and 781,105 gallons of rum.

The French East Indies sent four samples of arrack and punch.

The thirty-one exhibits of Martinique contained apricot brandy, rum, pine-apple wine, orange wine, and rum shrub, a sort of punch.

Mayotte sent two samples of rum.

New Caledonia showed eight samples of orange wine, brandy made from manioc, dracuena, tamarinds, and rum.

The Réunion Islands sent fourteen exhibits of rum and liqueurs. During the last ten years the domestic consumption of rum has increased to 18,715 hectolitres from 14,445, and the export to 12,226 from 1,137. The liqueurs exhibited were Crême de Combava, Curaçao, Crême de Vanille, etc. Some of these were of very fair quality.

The exhibit of Senegal was a wine called "Tabaskire."

Tahiti sent two specimens of rum.

The exhibit of Annam-Tonquin was a liqueur sent by a firm in Cognac.

Tunis sent only twenty-six exhibits of wine, brandy, bitters, and liqueurs. Tunis now has some 9,000 acres planted in vines. Well made ordinary wines are offered f. o. b. at Tunis at from 16 to 24 cents a gallon.

None of the wines shown were more than three years old. A large proportion of the plantations of Tunis is composed of American vines.

The Argentine Republic exhibited one hundred and sixteen samples of grape brandy, red and white wine, beer, sherry, rum, alcohol produced from molasses and Indian corn, champagne, vermuth, gin, and liqueurs.

Austria-Hungary sent twenty-six exhibits of Hungarian wines, one of Austrian, and one of Transylvanian.

Australia had forty exhibits. The wines of Australia made more impression on the minds of the jury than those of any other country, except Chili. It was considered that their progress had been very marked, and that they were now entirely fit to take their place in the commerce of the world by the side of the ordinary French country wines.

The exhibits included wines of all vintages since 1881; they met generally with high praise, and the most brilliant future was predicted for this industry. The imports of these wines into Great Britain have been:

	Imperial gallons.
1885	63,295
1886	148,404
1887	168,188
1888	232,939

The importation during 1889 has been at the rate of about 335,000 imperial gallons per annum.

Belgium showed eighty-nine specimens of beer, one exhibit of the red wine of Huy, one of bitters and cordials, and one of gin and alcohol.

Brazil sent twenty-nine exhibitors, who showed beer, wine, spirits, rum, and cordials. Wine is made in Brazil in the provinces of Rio Grande do Sul, Sâo Paulo, and Minas Gerces. Some artificial wines are also manufactured in the Republic.

The Cape of Good Hope showed three exhibits of wine of very good quality.

Chili had eighty-four exhibits, containing red and white wine, brandies, spirits, beers, liqueurs, and gaseous waters.

The wines produced a remarkably good effect on the jury, and were unanimously spoken of as being quite equal to the ordinary growths of the Gironde. The wine production of Chili for 1888 was something less than 1,000,000 gallons.

Cuba's two exhibits were liqueurs and alcohols.

Denmark sent six exhibits of beer. alcohol, brandy, punch, essences, and liqueurs.

The Dominican Republic sent thirteen exhibits, chiefly of rum, but there were also a few bottles of fruit wine and honey vinegar.

Egypt made two exhibits, one of Chiaura wines, and one of wine and brandy from the French missionaries at Samos.

The Republic of Ecuador sent seven lots of rum, alcohol, beer, wine, etc.

Next to France and her colonies, Spain had the largest number of exhibitors, in all six hundred and nineteen. They exhibited wines from all the different parts of the kingdom, although the names of some of the largest sherry shippers were conspicuous by their absence. There were also a few samples of brandy, liqueurs, and vinegar.

A full list of the fifty-seven exhibitors from the United States is given below.

The twenty-five exhibits from Great Britain were made up of Australian wines, Irish and Scotch whisky and beer, together with a few bottles of cider and perry. It was sufficiently evident that the beverages of Britain were not looking for a market in France.

The eighty-three exhibitors of Greece made up a very fine exhibit of Greek wines, brandy, and alcohol.

Guatemala exhibited nine lots of brandy, alcohol, liqueurs, and beer, but no wine. Among the exports from this country in 1888 were 8,860 gallons of alcohol.

Haiti sent to the Exposition two samples of rum.

The Government of Hawaii sent a sample of the native liqueur, okolehao, and one of squash wine.

Honduras sent fourteen samples of spirits.

The forty-five exhibitors from Italy showed a fair assortment of wine from different parts of the kingdom, including Sicily, liqueurs, vermouth, and a few lots of beer.

Japan sent thirty-two exhibits. With the exception of three or four made up of extracts, vermouth, and beer, they were all saké, a kind of wine or beer fermented from rice.

There was a sample of wine produced in the Department of Hiogo from some vines imported from France in 1878. The climate was ill-suited to them, however, and the wine was poor.

The Grand Duchy of Luxembourg had one exhibit of beer.

The exhibit of Mexico included some wines that were pronounced very good, although lacking in bouquet, beer of a fair quality, sugar cane brandy, mescal, and liqueurs.

The principality of Monaco sent four exhibitors with samples of wine, brandy, sirups, lemonades, and gaseous drinks.

Norway exhibited twelve lots of beer, fruit wine, alcohol, and punch.

Nicaragua had eleven exhibits of rum made from the sugar cane.

Paraguay sent five exhibits of rum, orange wine, and various liqueurs.

Persia and Peru each sent a few samples of wine. The most esteemed wines in Persia are those of Shiraz, but the vintage of Ispahan and others are also much sought after.

The Netherlands exhibited twenty-one lots of beer, alcohol, liqueurs, and gin.

The Philippine Islands sent one sample of alcohol and one of pineapple brandy.

Next to Spain, the largest foreign exhibitor in Class 73 was Portugal. Her five hundred and twenty exhibitors showed such a collection of red and white wine as has rarely been gotten together. There were also a few samples of brandy of no importance.

The Portuguese Colonies exhibited thirteen lots of brandy made from oranges, mandarins, and sugar cane, together with a few bottles of wine.

Porto Rico had twelve exhibits of spirits, chiefly molasses rum.

Roumania made sixty-three exhibits of excellent red and white wines, brandy, and liqueurs, including absinthe. The annual production of the country was given by the natives at 231,255,006 gallons, and they say it commands 27 cents a gallon, but I am inclined to think both of these statements somewhat exaggerated.

The wines sent from Russia, and particularly those from the government of Crimea, elicited much approbation from the jury. Others were shown from Bessarabia, Caucasus, and Turkestan. The total number of exhibits from Russia was seventy-seven, including wines, alcohol, three exhibits of sparkling wine from the government of the Don, brandy, liqueurs, koumiss, and beer.

The Grand Duchy of Finland sent four exhibitors with samples of alcohol, brandy, liqueurs, Swedish punch, and beer.

San Marino sent from its small territory ten exhibits of wine and one of absinthe.

The Republic of Salvador sent exhibits of liqueurs and brandy.

The forty-eight exhibits of Servia were pretty equally divided between wine and brandy.

The South African Republic made one exhibit, consisting of brandy and liqueurs.

Sweden exhibited some Swedish punch and a sample of beer.

The eighty-two exhibits of Switzerland included brandy, absinthe, vermouth, kirschwasser, red and white wine, dark and light beer, gin, honey brandy, Alpenkrauter magen bitter, cordials, liqueurs, and one sample of cholera medicine. The average annual production of wine in Switzerland is about 30,360,000 gallons, which is valued at 31 cents, but this price is too high.

Uruguay exhibited seven lots of red and white wine, liqueurs, vermouth and beer.

Venezuela sent eight exhibits composed of rum, bitters, orange wine, sugar brandy and liqueurs.

The official list of exhibits from the United States in Class 73 is as follows:

Rutherford Adamson, Napa County, California: Wines, assorted, from his vineyard at Napa.

American Wine Company, St. Louis, Missouri: Wines of the islands of Lake Erie, in Ohio.

Beadleston & Woerz, 291 West Tenth street, New York, New York: Lager beer. ale, and porter.

Adolphe Beck, San Francisco, California: Wines: Sauvignon, Cabernet, Port, and Burgundy.

Ben Lomond Wine Company, Mr. Wilkens, agent, Santa Cruz County, California: White wine, vintage of 1886.

Bergner & Engel Brewing Company, Philadelphia, Pennsylvania: Malt liquors.

Beringer Bros., St. Helena, Napa County, California: Wines and brandies.

Bolen & Byrne, 416 to 423 East Fifty-fourth street, New York, New York: Golden Russet champagne cider, mineral waters, ginger ale, and other aerated beverages.

A. Brun & Company, Nouveau Médoc, Oakville, Napa County, California: Wines: Riesling. Catawba, Carignane, Zinfandel.

California State Viticultural Commission "experimental cellar," San Francisco, California: Five cases assorted wines of California, various brands and vintages.

A. G. Chauché, Mont Rouge vineyards, Livermore, Alameda County, California: Wine from a blend of Sauvignon Blanc, Semillion and, Muscatel de Bordelais.

H. W. Crabb, To Kalon vineyard, Oakville, Napa County, California: Three cases Wine, assorted, Sauternes Tokay, Gutedel, Muscatel, Chambertin, etc.

F. W. Craft, Shore, North Carolina: Wine.

W. O. Craig, Sonoma, California: Wines: a blend of Riesling and Chasselas, vintage of 1885.

Charles Dadant & Son, Hamilton, Illinois: Wine and vinegar from honey.

J. De Turk, Santa Rosa, Sonoma County, California: Four cases of assorted wines: Riesling, Zinfandel, Sherry, brandy.

Edge Hill Wine Company, St. Helena, California: Wines: Cabinet Riesling, Golden Chasselas, Zinfandel, Burgundy, and brandy.

Ewer & Atkinson, Rutherford, Napa County, California: Wines: Sauvignon vert, Riesling, Zinfandel, Burgundy, Lenoir.

Fible & Crabb, Eminence, Kentucky, and Boston, Massachusetts: Bottled whisky.

Florida Wine Company, Clay Springs, Florida: Orange wine.

Gast Wine Company, St. Louis, Missouri: Wines: Norton, Iowa, Taylor, riesling, etc.

Alfred Greenbaum, San Francisco, California: Three cases wine, assorted, from vineyards in a mountainous region.

J. Gundlach & Company, San Francisco, California: Ten cases assorted wines from their Rhinefarm (Sonoma) vineyards.

Henry Hagner, Cedar Knoll vineyards, Napa County, California: Wines and brandy: Riesling, Zinfandel, Port, Angelica, Malaga, etc.

Haraszthy, Arpad & Company, San Francisco, California: Eclipse extra dry, Eclipse Brut, Riesling Gutedel, Zinfandel, etc. Mostly from Orleans vineyards, Yolo County.

Prof. W. E. Hilgard, University of California, Berkeley, contributor: Condensed must samples.

J. Holbrook & Sons, South Sherborn, Massachusetts: Ciders, champagnes, etc.

George F. Hooper, Sobre Vista Vineyard, Sonoma, California: Wines: Riesling, Zinfandel, Muscatel, and brandy.

Hume & Co., 807 Market Space, Pennsylvania avenue, Washington, District of Columbia, Old Stag whisky and old apple brandy.

Prof. George Husman, Napa City, California: Wines of California.

Charles Krug, St. Helena, Napa County, California: Case of wines, assorted, including Mondeuse, Sweet Muscatel, and brandy.

Kohler & Frohling, San Francisco, California: Eight cases wine and brandy, assorted, from their Glen Ellen vineyards.

Joseph Kunz, New York City: Beer.

J. Matthews, Lisbon Winery, Napa, California: Case of selected wines: Riesling, Zinfandel, Sherry.

G. Megliavalla, Napa, California: Claret wine made in Napa Valley.

Monticello Wine Company, Charlottesville, Virginia: Wines: Cynthiana, Norton, Clinton, Ives, etc.

Moore & Sinnott, Philadelphia, Pennsylvania: Gibson's pure rye and barley malt whisky.

S. R. & T. G. Mott, 118 Warren street, New York, New York: Sweet and Golden Russet carbonated cider.

J. V. Munson, Denison, Texas: Collection of native wines.

Napa Valley Wine Company: Cellars at Napa; commercial business at San Francisco, California: Five cases wines: Carignane, Burgundy, Cabinet, Sauvignon, Gutedel, Tokay, and brandy.

New Urbana Wine Company, Hammondsport, New York: Gold Seal, Port, sweet and dry Catawba, etc., etc.

Nouveau Clos Vougeot vineyard; V. Courtois, manager; St. Helena, Napa County, California: Three cases wines, assorted brands and vintages.

John Osborn, Son & Company, New York, Philadelphia, Montreal: Antediluvian pure rye whisky.

Alex. M. Pearson, Vineland, New Jersey: Burgundy and Ironclad.

Pleasant Valley Wine Company, Rheims, Steuben County, New York: Great Western Extra Dry, Delaware, Catawba.

Purity Wine Company, San Francisco, California. Red and white wines, treated by an electric process.

Adolph Russow, Proffit, Virginia. Wine: Norton.

G. F. Ryckman, Brocton Wine Company, Brocton, New York. Imperial Champagne, Brocton Port, Catawba, Niagara, etc.

C. Schilling & Company, San Francisco, California: Five cases wine: Cabernet, Sauvignon, Burgundy, Zinfandel, Semillon, and others.

Jacob Schram, St. Helena, California: Wines from his mountain vineyards: Hock, Riesling, and Burgundy.

Sonoma Wine and Brandy Company, 1 Front street, New York City: Specimens from cellars of George West, Stockton, California.

Stone Hill Wine Company, Hermann, Missouri: Catawba, Riesling, Rulander, Concord, Norton, etc.

To Kalon Vineyards, H. W. Crabb, proprietor, Oakville, California: Claret, Zinfandel, Chambertin, Burgundy, Riesling, etc.

August Vogt, Willow Point, Texas: Twelve bottles of native wine of Texas.

University of California experimental cellar, Berkeley County, California: Wines (assorted), vintage of 1888.

Charles A. Wetmore, Livermore, Alameda County, California: A selection of table wines: Médoc, Sauternes, etc., from the Cresta Blanca vineyard.

Mrs. J. C. Wineberger, St. Helena, California: Wines, sherries, and brandy, assorted.

II.—THE AWARDS.

The following is a detailed list of the awards to all countries in the four sections of the class.

Country.	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.
WINE AWARDS.					
France	3	206	452	289	303
Algiers	....	102	349	147	195
Spain	3	85	286	136	179
Portugal	3	63	199	24	88
Tunis	1	6	11	6	1

Country.	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.
WINE AWARDS—continued.					
Switzerland	....	4	11	7	3
Russia	1	2	17	11	9
Servia	....	3	16	7	6
Brazil	1	2	7	4	6
Mexico	....	1	5	2	8
Greece	....	8	18	11	12
United States	....	3	12	13	8
Italy	1	7	7	9	4
Australia	1	8	19	8	3
Chili	1	7	23	7	1
Roumania	....	4	5	2	8
Austria-Hungary	....	2	11	4	9
Argentine Republic	....	2	10	3	2
Egypt	....	1	2	1	....
Belgium	....	1	....	....	....
Uruguay	....	1	3	1	1
Bolivia	....	....	....	....	1
Persia	....	1	....	....	....
Cape of Good Hope	....	1	1	1	....
Great Britain	....	....	1	....	....
Peru	....	....	1	....	....
Dominican Repubiic	....	....	2	....	....
Japan	....	....	2	....	....
San Marino	....	....	1	1	1
Monaco	....	....	1	....	1
Ecuador	....	....	1	....	....
SPIRIT AWARDS.					
France	5	54	126	78	40
Algiers	....	15	26	41	37
Spain	2	7	23	26	5
Portugal	....	5	7	18	7
Switzerland	....	4	7	6	11
Russia	1	7	7	8	13
Brazil	1	1	1	3	2
Belgium	1	1	4	1	3
Martinique	....	5	6	6	8
Netherlands	1	1	11	4	....
Venezuela	....	2	16	3	5
Great Britain	....	2	4	6	1
United States	....	2	3	3	2
Mexico	....	6	13	17	29
Denmark	....	2	1	....	1
Guatemala	....	....	....	2	1
Argentine Republic	....	2	11	8	10
Servia	....	2	[illegible]	7	24
Tunis	....	3	1	1	8
Norway	....	3	1	....	....
Japan	....	5	11	12	1
Guadeloupe	....	2	8	5	9
Roumania	....	1	5	6	1
Bolivia	....	....	2	....	....
Greece	....	1	....	....	2
Dominican Republic	....	1	1	1	3
Réunion Island	....	1	1	2	1
Uruguay	....	2	3	3	2

Country.	Grand prize.	Gold medal.	Silver medal.	Bronze medal.	Honorable mention.
SPIRITS AWARDS—continued.					
Chili		1	8	7	1
Isle Mauritius		1			
Portuguese Colonies			6	2	5
St. Pierre de Miquelon					1
Sweden		1	1		
Austria-Hungary			2		1
Haiti			1		
Honduras			1	11	
Ecuador			2	1	1
Paraguay			1	2	
Italy			1		3
Egypt			2		
Gaboon Congo			1		
Mayotte			1		
South African Republic			1		
Salvador			1		
Tahiti					
Annam-Tonquin				1	
Hawaii				1	2
New Caledonia				1	2
BEER AWARDS.					
France	2	17	22	14	
Algiers			1	3	2
Spain		1	3		
Portugal			1		
United States	1	3			
Belgium	2	16	12	6	4
Norway		4	2		
Denmark	1				
Netherlands	1	2	1		
Argentine Republic		2	2	2	1
Switzerland		2		1	
Great Britain		5	3	2	
Chili		4	5	3	
Brazil		2	2	2	
Sweden		1			
Luxembourg		1			
Uruguay		2	1		
Japan		1	3	1	
Uruguay		2	1		
Japan		1	3	1	
Servia		1			
Finland			1		
Terre Neuve			1		
Mexico			1		1
Russia			1	2	1
Ecuador			1		
Italy			2	1	1
Australia			1		
CIDER AWARDS.					
France		8	32	26	16
United States		1			
Great Britain			1		

The following is a detailed list of the awards to American exhibitors:

Section 1.—Wine.

GOLD MEDALS.

A. G. Chauché, Mont Rouge Vineyards, Livermore, California.
G. Megliavalla, Napa, California.
Charles A. Wetmore, Livermore, California.

SILVER MEDALS.

Adolph Beck, San Francisco, California.
Beringer Brothers, St. Helena, California.
Alfred Greenbaum, San Francisco, California.
Arpad Harazthy & Co., San Francisco, California.
Henry Hagner, Napa County, California.
George F. Hooper, Sonoma, California.
Kohler & Frohling, San Francisco, California.
Monticello Wine Company, Charlottesville, Virginia.
New Urbana Wine Company, Hammondsport, New York.
Pleasant Valley Wine Company, Rheims, New York.
C. Schilling & Co., San Francisco, California.
Stone Hill Wine Company, Hermann, Missouri.
J. De Turk, Santa Rosa, California.
Mrs. J. C. Weinburger, St. Helena, California.

BRONZE MEDALS.

American Wine Company, St. Louis, Missouri.
H. Aubonin.
A. Brunn & Co., Oakville, California.
Courtois & Co., Nouveau Clos Vougeot Vineyard, St. Helena, California.
W. O. Craig, Sonoma, California.
J. Gundlach & Co., San Francisco, California.
Charles Krug, St. Helena, California.
J. Matthews, Napa, California.
Purity Wine Company, San Francisco, California.
Adolph Russow, Proffit post-office, Virginia.
Rutherford Adamson, Napa County, California.
G. F. Ryckman, Brocton, New York.
University of California, Berkeley, California.

HONORABLE MENTION.

Ben Lomond Wine Company, Santa Cruz County, California.
Edge Hill Wine Company, St. Helena, California.
Ewer & Atkinson, Rutherford, California.
Florida Wine Company, Clay Springs, Florida.
H. Grossman, Napa, California.
Alexander N. Pierson, Vineland, New Jersey.
Gast Wine Company, St. Louis, Missouri.
Jacob Schram, St. Helena, California.

SECTION 2.—SPIRITS.

GOLD MEDALS.

California State Viticulture Commission, San Francisco, California.
John Osborn, Son & Co., New York.

SILVER MEDALS.

H. Hagner, Napa County, California.
Hume & Co., Washington, District of Columbia.
Napa Valley Wine Company, San Francisco, California.

BRONZE MEDALS.

H. W. Crab, Oakville, California.
Edge Hill Wine Company, St. Helena, California.
J. De Turk, Santa Rosa, Sonoma County, California.

HONORABLE MENTION.

Charles Krug, St. Helena, California.
Nouveau Clos Vougeot Vineyard, St. Helena, California.

SECTION 3.—BEER.

GRAND PRIZE.

Bergner & Engel Brewing Company, Philadelphia, Pennsylvania.

GOLD MEDALS.

Beadleston & Woerz, New York City.
Joseph Kunz, New York City.
Montgomery Brewing Company, Montgomery, Alabama.

SECTION 4.—CIDER.

GOLD MEDAL.

S. R. & T. C. Mott, New York.

It will be observed that for her eighty-seven exhibits, the United States received eighty-one awards.

III.—WINES.

The writer desires to express his thanks to Messrs. William Wood & Co., of New York, for their courtesy in permitting him to use, in making up this report, the article on wines, spirits, and beer in the last edition of their Reference Handbook of the Medical Sciences.

COMMERCIAL IMPORTANCE OF WINE PRODUCTION.

The total production of wine in the world is something like 3,000,000,000 gallons a year, of which Italy, France, and Spain contribute at present about 2,000,000,000 gallons; Austria, Hungary,

Germany, and Portugal about 350,000,000 gallons, and Russia and Algiers about 175,000,000, leaving about 575,000,000 for the rest of the world. Of course, these figures vary materially from year to year; for instance, the French crop in 1875 was 2,217,600,000 gallons, and the figures are difficult to handle and understand, as is very well shown in the report made to the Commissioner of Agriculture in 1887, by Mr. G. A. Crampton, where the wine production of Algiers for 1884 is given at 722,000,000 imperial gallons. It was probably less than 22,000,000. But 3,000,000,000 American gallons is about the wine production of the world in 1889, and outside of the eight countries named, there is none producing as much this year as 50,000,000 gallons.

CONSUMPTION AND PRODUCTION OF WINES.

Wine, properly so called, is the product of the fermentation of grape juice. This fermentation is induced by the growth of the ferment germs that are found on the skins and stems of the grapes, and in large quantities in all places where fermentation is going on. Grape juice, left to itself, and preserved from the action of these germs will not ferment. Various other decoctions are manufactured in their idle moments by ambitious housewives, from currants, gooseberries, plums, etc., but these should not be dignified by the name of wine, and it may be added that, to all amateurs contemplating making any kind of wine, the advice given should be the same as that recommended of old time to persons contemplating matrimony. No skill or care can be too great to be applied to wine-making, and those who are unable or unwilling to give to the task a very great deal of both should not attempt it. In other words, on being confronted with a sample of wine that does not come from a vineyard whose proprietors are possessed of long experience and great skill, either in their own person or that of their employés, one may be reasonably certain that the wine is bad.

Among the chemical constituents of wine are found gelatin, gum, fat, wax, albumen, gluten, tartaric acid, potassic tartrate, racemic acid, malic acid, calcic malate, oxide of manganese, oxide of iron, potassium sulphate, sodium chloride, calcium phosphate, magnesia, silicic acid, tannic acid, and some other matters. The proportions of these elements vary in different wines, but it is probable that, barring the question of the taste of the patient, all of them, with the exception of alcohol and tannic acid, may safely be left out of consideration when we come to regard their prophylactic and therapeutic efficacy.

The substances that impart the endless variety of flavor and bouquet to the numberless different wines of the world have not as yet been detected by chemistry, and it is only by the finer processes of smell and taste that we are able to distinguish them.

If the wine made from purple grapes is not allowed to ferment on the skins, its color will be white like champagne; if it is, the result will be a red wine. The tannic acid of wine is also formed in the skins, so that generally we may safely assume that the darker a wine is, the more tannic acid it contains. If two wines of equal alcoholic strength be taken, it will be found that equal doses of each will produce their effect much more quickly in the case of the white wine than in that of the red. The reason of this is that the astringent action of the tannic acid retards the effect of the alcohol upon the organism. It may be that this indicates in a general way the superiority of white wines as stimulants and red as tonics. Some tannic acid is also derived from the stones and stalks when these are allowed to ferment with the juice of the grapes.

The quality of the soil upon which the vines are grown, as well as the nature of the manures used to stimulate it, exercises a very decided influence on the quality of the wine. The best wines are grown in clayey, sandy, and slaty soils of indifferent value for cereal growths. The best Burgundy comes from a clayey-lime soil; a large proportion of lime is found in the best districts of Champagne; the Gironde is mainly made up of sand and shale. The volcanic soil of Madeira, which produces some of the noblest wines we know, would hardly support life in any other vegetation. Fetid manures, such as fecal matters and sewage, have a bad effect on the bouquet of the wine. The leaves of the vine make an excellent manure for the parent vine, and at the vintage they are allowed to remain on the ground and frequently furnish it with sufficient food. No fact has been better established than that the soil will affect the quality of the wine produced from it. The notion so firmly held and fondly cherished by many growers, particularly among Americans, that certain grapes will produce the same wine in different soils and different countries, is, I think, entirely untenable.

Next in importance to the soil, as affecting the character of the wine, is the temperature. In general, the higher the average temperature for any given region, the larger will be the quantity of wine produced and the greater the proportion of alcohol. It does not follow, however, that the quality will be proportionate to the quantity, for very frequently those years that excel in quantity are the poorest in quality. The action of the sun in ripening the grapes is of the very highest importance. For this reason, in wine-growing countries, the vines are not generally allowed to grow high, but are kept at a height of about three feet; this exposes the grapes to the direct action of the sun, as well as to the reflection from the ground; the ripening is also carried on during the evening and night by the heat then given off by the earth. This system does not, as might be supposed, increase the quantity of juice obtained, for in some districts where both systems are in use, the quantity of juice obtained is greater

in the vineyards where the vines are allowed to grow higher, but the quality of the wine is not so good.

Having the proper soil and temperature, the next question for the making of a good wine is the grape. Of these the varieties are innumerable; some of them will be mentioned in the course of this article in speaking of the characteristics of the different vintages. It is possible in transplanting a vine to perpetuate some of its qualities in a certain degree for a certain period of time, but they change rapidly under the influence of changed conditions of soil, climate, etc., so that, as has already been remarked, the idea of reproducing any grand wine in another country must be looked upon as the dream of an enthusiast. No one would say that Schloss Johannisberger was better than Château Lafite, or *vice versa*, but he would be but an ignoramus who should think of growing the nectar of the Médoc on the German mountain.

It is quite customary, in making wines of certain qualities, to throw two or more varieties of grapes into the fermenting vats ; this method will not produce the best wine. In order to secure that, but one kind of grape must be used. Care must be taken therefore, when several varieties of grapes are bought or grown together, to separate them before pressing. This is more especially the case when the grapes are of different colors, as the purple grapes, transmitting the heat of the sun more readily, ripen from ten to twelve days earlier than the white, which, consequently must be separated in order to avoid making a green, sour wine.

Some authorities are of the opinion that soils which have once produced very excellent wine will in time deteriorate and be no longer capable of producing the same quality, and various cases are instanced where this change is supposed to have taken place. It is more than probable, however, that such changes as have really taken place in the quality of these wines are properly to be attributed to a lack of care or to a change in the system of cultivation. Much, perhaps, is due to a change of taste in the consumer.

Wines made from white grapes, when allowed to ferment on the skins, acquire with age a dark color that is due to the action of the oxygen of the atmosphere on the tannic acid of the skins. This action is familiar to us in the case of raisins, which are always brown, although generally made of white grapes. That this change of color is not due to drying, is shown by the fact that when raisins are soaked in water they do not regain their original color, but remain brown. The coloring matter contained in grape skins may be obtained in the following manner : Soak the skins in dilute acetic acid, precipitate with lead acetate, wash the precipitate, suspend it in water, pass sulphuretted hydrogen through it, filter off the lead sulphide, boil the water, treat with alcohol and acetic acid, evaporate the liquid, and free the residue from fat by means of ether.

The coloring matter is blue. It is more easily soluble in alcohol and tartaric acid than in tartaric acid and water, and is, therefore, easily removed from the skins by the juice of the grapes, which contains tartaric acid, and more readily during the process of fermentation when the quantity of alcohol is continually increasing. The action of acids makes it red. Therefore, in unripe grapes, which contain a great deal of acid, it is red, and as the grapes grow ripe the diminution of the acid causes them to grow bluer. The less acid the grapes contain, the darker are the skins, and, consequently, the darker is the wine fermented on them. Very sweet grapes often have skins nearly or quite black.

The quality of the wine depends very much upon the care taken in selecting the grapes at the vintage. A perfect wine can be made only from perfectly ripe grapes, and if unripe grapes or overripe and decaying ones are permitted to go into the press, the result is certain to be an inferior wine.

The character of the fermentation depends very much upon the quantity of juice set in fermentation at once. It is generally considered that the fermentation is better and more equally developed, other things being equal, in large than in small quantities.

When a season has been bad, owing to cold weather and an excess of rain, the juice will be lacking in sugar and develop too much acid. In such cases sugar is often added, and when the fermentation is finished this addition can not be detected by any means known to chemistry. Different views are entertained by different wine-merchants in regard to the propriety of such so-called "improvements," but they will be considered in more detail in another part of this article.

The process of fermenting wine is as follows: The grapes, having been pressed, the juice is collected in a receptacle, and soon afterward the liquid seems to be in motion; little bubbles rise to the surface, the juice becomes more turbid, the motion of the liquid increases, and froth forms on the surface. By degrees the bubbles grow larger, and as more alcohol is generated the lighter liquid is no longer able to hold in solution matters it contained, and some of them fall to the bottom. The fermentation reaches its highest point with more or less rapidity, according to the temperature. In a moderate autumn climate this generally occurs in from three to four days. When the fermentation is growing less violent, but before it ceases entirely, the whole mass is stirred up so as to bring all of its components into fresh contact. In the early days of wine-making it was customary in many districts to introduce into the wine tub a naked man, who stirred up everything, and the warmth of whose body was supposed to promote fermentation. Several deaths are recorded of such individuals from breathing carbonic acid. The practice has now fallen into desuetude. After the fermentation has gone on for

three or four days it begins to diminish, and the wine by degrees, clears itself, the sediment sinking to the bottom. When the wine is sufficiently clear it is drawn off into another receptacle and the fermentation (now called the after fermentation) is allowed to go on for several months, alcohol continually generating and the sediment dropping to the bottom. The increase of fermentation that takes place in the spring, owing to the increased temperature of the season, is poetically attributed by old vineyardists to the fact that the wine remembers the blossoming of the vines. When the wine can be drawn off clear, it is put into casks and placed in the cellar.

In order to render the wine perfectly clear various substances are used, such as isinglass, blood, milk, cream, albumen (the white of eggs), nutgalls, lime, etc. These generally have a merely mechanical effect, but some of the alkalies take up some acid.

The practice of cleansing casks by burning sulphur in them is a very common one among wine-makers. It is done by burning sulphur in the cask, into which the wine is introduced immediately afterward. The sulphurous acid hinders fermentation by uniting with the albuminous substances in the wine and rendering them inert. This practice is particularly applied to sweet white wines, which possess an excess of sugar and albumen. Pulverized mustard seed is sometimes used instead of sulphurous acid.

In keeping wines in cellar the larger the cask the less will be the surface exposed to the air in proportion to the contents. On this account it is customary among handlers of wines to employ casks as large as possible. The largest one in the world is the Königstein tun; it contains considerably more than the renowned Heidelberg tun; the third in size belongs to the Lenk Wine Company, of Toledo, Ohio; it holds thirty-six thousand gallons, and was built by Müller Brothers, of Toledo. When wine is stored in smaller casks, as is generally the custom in France, the casks are kept filled, this object being sometimes accomplished by filling a bottle of wine and inverting it in the bunghole, so that the loss by evaporation is continually made good by the wine from the bottle.

Wine that is properly kept will last to a great age. An instance is recorded in the Journal of Science, Vol. I, p. 136, in which some Malaga wine that was buried during the great fire in London, in 1666, was found, when dug up in 1817, to be in good condition and of normal taste. But under ordinary circumstances every wine has a certain life which varies from a few months up to a hundred years, according to its character and the manner in which it is cared for. This point will be discussed more particularly when we come to consider the different varieties of wines; but it may be laid down as a general rule that the more albuminous matter and sugar, and the less alcohol and tannic acid a wine contains, the sooner its career will be finished. Under ordinary hygometric conditions, wine kept

in leather bottles or in wooden casks will gain in alcohol. This will be considered more at length under the head of spirits. In aging wines, then, as it is mainly water that is evaporated, the alcohol and other vinous elements of the wine become more concentrated and the wine improves in character and flavor. When it has reached a certain point in this improvement it is said to be "bottle-ripe," and should then be put into bottles. Its improvement after this goes on more or less rapidly, but the further increase in alcohol is insignificant. Red wines in bottles that are rich in tannic acid, like port, for instance, deposit a sediment and grow lighter in color. Those that contain less tannic acid generally grow darker. The cause of this is a gradual diminution in the quantity of free acid in the wine. The effect of this acid, as has been pointed out, is to turn the coloring matter red, and as it diminishes, therefore, the wine grows darker or more purple. It would carry us beyond our limits to enter into the question of this diminution of acids, and the reader who wishes to study this point is referred to the admirable monograph on the chemistry of wine by Prof. Mulder, of the University of Utrecht.

The disagreeable taste that is found sometimes in wine, and which is known as the taste of the cork, arises from mold; the moist cork, one end of which is in contact with the wine and the other exposed to the air, permits the growth of mold plants, the smell of which is discernible in all old wine cellars. The growth of this mold is from the outside to the inside, and if it is permitted to go through the cork it ruins the wine. The same process goes on through the wood of old casks. It is very common in wine cellars not properly attended to, for the proprietor to meet with a bitter disappointment from this cause when he presents to his guests a sample of some valuable old vintage. It is therefore necessary, from time to time, in order to preserve the wine in perfect condition, to cleanse thoroughly the casks inside and out, and to change the corks in the bottles, even when the old ones seem to be in good condition. If the inside of the cork be covered with rosin or sealing wax the entrance of air is prevented, and the growth of the mold hindered, although this does not stop it entirely.

Wine improves with time and warmth, and some successful experiments have been made in improving it by cold. It begins to solidify at about — 10° to — 12° C. (10.4° to 14°F.). The ice that forms consists principally of water, and the remaining liquid improves in alcoholic strength. Some agreeable surprises have occurred in this way to owners who, supposing that their property was ruined, were delighted to find, on examination, that its quality was improved.

Wines are subject to various diseases, among which may be mentioned "turning"—caused by decomposition of potassium tartrate—ropiness, the formation of vegetable mucus, bitterness, acidifying, moldiness, etc. Various remedies are known for the cure of these

diseases, but they require great skill in the application, and if an owner finds that his wine has gone wrong, it is best to call in immediately the services of an experienced wine merchant.

When red wine is mixed with carbonated waters, as Vichy, for instance, the potassium carbonate of the water saturates the free acid of the wine and so destroys the red color and permits it to become darker, while the action of the alkali upon the coloring matter gives it a cloudy appearance which grows more pronounced in proportion to the preponderance of the alkali and the length of time it is permitted to act upon the coloring matter.

The question of the constitution of the substances that give wine its aroma is involved in much obscurity. The one that exists in the largest proportion makes up only $\frac{1}{40000}$ part by weight. Still, a number of substances have been determined, and we may name them and state some of their characteristics. The one that is found to exist in all wines, and which imparts to them the characteristic odor, is œnanthic ether, $C_7H_{13}O_2C_2H_5$. The following are not found in all wines, but one or several of them are found combined with œnanthic ether in all aromatic wines; acetic ether (acetate of ethyl); this ether appears in nearly all aromatic wines and is developed in them by time. This fact is well known to adulterators, and acetic ether is regularly sold for the purpose of improving the bouquet. A few drops are enough for a bottle. Butyric ether, $C_4H_7O_2C_2H_5$, and caprylic ether, $C_8H_{15}O_2C_2H_5$; both of these have the fragrance of pineapple. Among others may be mentioned caproic ether, pelargonic ether, capric ether, acetate of capryl, propionic ether, butyl alcohol, and the hydrate of amyl (amylic alcohol). These and various other compounds of similar composition, the difficulty of whose identification will be apparent to every chemist, are found in varying quantities in different wines and will account for the infinite variety of bouquet. As a rule, the largest proportion of odoriferous ingredients is found in wines containing free acids. Very sweet wines, containing little free acid, or those in which this is softened by an excess of sugar, are generally much less fragrant than dryer wines. If grape juice be filtered through animal charcoal and then allowed to ferment, or if it be evaporated and the residue mixed again with water and allowed to ferment, or if the juice be mixed with olive oil and fermented after the oil is separated from it, the product in each case will be a wine without any aroma. Some grapes have an aroma of their own which persists in wine prepared from them. The Muscatelle is the most striking example of this. Various plants are used to increase the bouquet of different wines. Among these may be mentioned rose leaves, lime and elder flowers, the leaves of the meadow sweet, the peel of quince pears, the blossoms of wild vines, sage leaves, oil of centaury, violet roots, roots of the Florentine iris, etc. A fragrant ethereal oil has been

separated from raspberries by distillation, 30 kilograms of raspberries yielding 5 grams of the oil. This enables us to form an estimate of how extremely small the quantity of odor-giving substances must be in wine, as the most aromatic grapes possess hardly one one-hundredth part of the aroma of the raspberry. In determining the characteristics of the bouquet of wines chemistry is almost entirely at fault. Competent judges can determine by taste and smell differences entirely inappreciable by any method at present known to chemistry. They can easily distinguish the smell between peppermint water (*aqua menthæ*) prepared by distillation and that made by dissolving peppermint oil in water. Chemistry in either case finds only peppermint oil and water. Wines differing widely from each other in taste and smell are all one to chemical analysis.

The adulteration of wine is a bugbear about which much more talk has been wasted than it really deserves. In the larger wine-growing countries of the world it is difficult to find any substance possessing the requisite amount of alcoholic strength that is cheaper of production than wine, and some of the worst beverages offered for sale in the markets of the world are perfectly pure wine. Wine is said to be "adulterated"—

(1) When some substance is added to it in order to give to young wine the aroma of old age.

(2) When sugar is added to sweeten it.

(3) When substances are added to remove or neutralize an excess of acid.

(4) When alumina or sulphuric acid is added (generally accompanied by the simultaneous addition of sugar) in order to improve the flavor.

(5) When coloring ingredients are added.

(6) When inferior wines are added to others.

(7) When water is added.

(8) When alcohol is added.

In general, when any substance is added to wine in order to give it some property that it does not naturally possess.

Some of these so-called adulterations are generally admitted by wine merchants to be entirely proper; and, indeed, in many instances they are necessary to bring out the best qualities of some wines, and as long as no substances deleterious to the health of the consumer are added, it is difficult to see that there is any great harm arising from any of the practices mentioned. With the exception of tests for coloring and sugar, in a general way, the best method of detecting any of these is that of taste and smell.

Large quantities of wine are made from raisins. The raisins are softened in water, and on being exposed to the proper temperature the liquor will ferment and produce a wine that chemistry can not

distinguish from any other. It is, however, flat in taste, and possesses but little bouquet, and may be known by the absence of what is called vinosity.

As has just been stated, the acidity, bitterness, putridity, oiliness, and other bad qualities of pure wines make up an aggregate that is worse than the vices of so-called adulterations; but it may be laid down as a general rule that if the consumer will take the trouble to taste carefully every beverage that he introduces into his system, a very little experience will make his nose and palate a sufficient safeguard against any harm that can come to him from this source. Other deceptions that are practiced on the unwary buyer will be spoken of elsewhere.

There is hardly a country in the world that has not at some time attempted, on a larger or smaller scale, to manufacture wine, and there is nothing so difficult as to convince the experimenters that they have not achieved a permanent success. Few persons in the world to-day have ever even heard of such a thing as English wine; but the following extract from a letter, written about a hundred years ago to Sir E. Barry, by Mr. Hamilton, of Painshill, will show how sanguine were the expectations at one time entertained of this vintage. After recounting some preliminary failures, Mr. Hamilton says:

That experiment succeeded far beyond my most sanguine expectations; for the very first year I made white wine it nearly resembled the flavor of Champagne, and in two or three years more, as the vines grew stronger, to my great amazement, my wine had a finer flavor than the best Champagne I ever tasted. The first running was as clear as spirits, the second running was *œil de perdrix*, and both of them sparkled and creamed in the glass like Champagne. It would be endless to mention how many good judges of wine were deceived by my wine and thought it superior to any Champagne they ever drank. Even the Duke de Mirepoix preferred it to any other wine; but such is the prejudice of most people against anything of English growth, I generally found it most prudent not to declare where it grew till after they had passed their verdict upon it. The surest proof I can give of its excellence is, that I have sold it to wine merchants for 50 guineas a hogshead; and one wine merchant, to whom I sold £500 worth at one time, assured me he sold some of the best of it from 7*s.* 6*d.* to 10*s.* 6*d.* per bottle.

BORDEAUX WINES.

In proceeding to consider the different classes of wines, the wines of the department of the Gironde, ordinarily called by English-speaking people Bordeaux wines, or, less properly, claret, should have the first place. Even the good Hamm, the great prophet of German wines, says:

France is the wine country of the world, not only on account of the quantity of her production, which certainly is not reached by any other country, but on account of the superior excellence of her wines. German patriotism may contest it if it will, but the fact can not be avoided: France produces better wine and more good wine than Germany. I think it necessary to remark that I drink only

such German wines as I have been accustomed to from my youth up, and I consider myself as good a German as the next one. Nor is this on account of their hygienic qualities; on the contrary, in this respect, I consider the German wines preferable.

Hamm goes on to give, as his reason for this opinion, the case of two German apothecaries, father and son, who, one at 88 and the other at 108, drank every day a bottle of German wine apiece, and made poetry, but never touched French wine; but, for reasons already given, he is probably wrong in this respect.

The vine was cultivated in France, as mentioned by Strabo, 600 B. C., and the wines of the Médoc were known and esteemed in Rome during the Empire.

The different districts in the vicinity of Bordeaux are known as (1) The Médoc, extending to the north of Bordeaux along the Gironde as far as its mouth. (2) The Graves, lying along the Garonne to the south and west of Bordeaux, a district about 40 miles in length and 16 in width. (3) The Sauternes, or "white wine" district, that stretches along the left bank of the Garonne, and to the southward, from 40 to 60 miles farther. (4) Éntre-deux-Mers, the district between the Garonne and the Dordogne, reaching from the easterly extremity of the white wine district to the point where the two rivers unite to form the Gironde. (5) The St. Emilionais. (6) The Libournais. (7) The Fronsadais. (8) The Bourgeais. (9) The Blayais, stretching along the north bank of the Dordogne from southeast to northwest, and so called from the names of their chief places, St. Emilion, Libourne, Fronsac, Bourg, and Blaye.

The following varieties of grapes, given in the order of their general merit, are those most in use in the Gironde: For red wines, Cabernet-Sauvignon, Gros-Cabernet or Carmenet, Cabernelle or Carmenère, Merlot, Malbec, Verdot, Sirha, Pignon, Mancin, Chausset, Teinturier, Bouton-blanc; for white wines, Sémillon, Sauvignon, Muscadelle, Blanc-Auba, Blanc-Doux, Blanc-Verdet, Ensageat, Prunelat or Pruéras, Blanquette, and Rochalin or Blayais.

The average vintage of the Médoc is about 14,000,000 American gallons, or 57,500 tuns, which is ordinarily divided into about 5,400 tuns of the classed growths, 26,750 tuns of bourgeois and premiers artisans, 22,150 tuns of artisans and paysans, and 3,200 tuns of palus.

The classed growths are divided into five classes, known as first, second, third, etc., growths. Their names and classes, together with the communes in which they are situated, are given below:

FIRST GROWTHS.

Château-Lafite	Pauillac.
Château-Margaux	Margaux.
Château-Latour	Pauillac.
Château-Haut-Brion	Pessac.

SECOND GROWTHS.

Mouton-Rothschild	Pauillac.
Rauzan-Ségla	Margaux.
Rauzan-Gassies	Margaux.
Léoville-Lacases	St. Julien.

SECOND GROWTHS—continued.

Léoville-Poyféré.......... St. Julien.
Léoville-Barton.......... St. Julien.
Durfort-Vivens.......... Margaux.
Lascombes.......... Margaux.
Gruaud-Larose-Sarget.......... St. Julien.
Gruaud-Larose.......... St. Julien.
Brane-Cantenac.......... Cantenac.
Pichon-Longueville.......... Pauillac.
Pichon-Longueville Lalande.......... Pauillac.
Ducru-Beaucaillou.......... St. Julien.
Cos d'Estournel.......... St. Estèphe.
Montrose.......... St. Estèphe.

THIRD GROWTHS.

Kirwan.......... Cantenac.
Château-d'Issan.......... Cantenac.
Lagrange.......... St. Julien.
Langoa.......... St. Julien.
Giscours.......... Labarde.
Malescot St. Exupéry.......... Margaux.
Brown-Cantenac (Boyd)... Cantenac.
Palmer.......... Cantenac.
La Lagune.......... Ludon.
Desmirail.......... Margaux.
Calon-Ségur.......... St. Estèphe.
Ferrière.......... Margaux.
Becker.......... Margaux.

FOURTH GROWTHS.

St. Pierre (Bontemps du Barry).......... St. Julien.
St. Pierre (Luetkens).......... St. Julien.
Branaire-du-Luc.......... St. Julien.
Talbot.......... St. Julien.
Duhart-Milon.......... Pauillac.
Pouget.......... Cantenac.
La Tour-Carnet.......... St. Laurent.
Rochet.......... St. Estèphe.
Château-Beychevelle.......... St. Julien.
Le Prieuré.......... Cantenac.
Marquis de Terme.......... Margaux.

FIFTH GROWTHS.

Pontet-Canet.......... Pauillac.
Babailley.......... Pauillac.
Grand-Puy-Lacoste.......... Pauillac.
Ducasse-Grand-Puy.......... Pauillac.
Lynch-Bages.......... Pauillac.
Lynch-Moussas.......... Pauillac.
Dauzac.......... Labarde.
Moreton d'Armailhacq.......... Pauillac.
Le Tertre.......... Arsac.
Haut-Bages.......... Pauillac.
Pédesclaux.......... Pauillac.
Belgrave.......... St. Laurent.
Camensac.......... St. Laurent.
Cos-Labory.......... St. Estèphe.
Clerc-Milon.......... Pauillac.
Croizet-Bages.......... Pauillac.
Cantemerle.......... Macau.

To give an idea of the value of these wines it may be sufficient to state the prices at which they sold in 1865, and their appreciation in value will be seen by the prices which they brought two years afterwards:

[Francs per tun (1,200 bottles)].

	Vintage, 1865.	Nov. 16, 1867.
First growths	5,600	7,000 to 8,000
Second growths (Mouton)	3,500	5,500 to 6,000
Second growths	2,500 to 2,600	5,000 to 5,500
Third growths	1,900	3,600 to 4,000
Fourth growths	1,500 to 1,600	3,000 to 3,400
Fifth growths	1,200 to 1,400	2,500 to 2,800
Bourgeois-supérieurs	1,000 to 1,200	1,800 to 2,000

In addition to the classed growths, there are some 2,500 vineyards in the Médoc that are registered and known by their names.

There are several different kinds of wine made in the Médoc vineyards. In a general way, these may be described somewhat as fol-

lows: The wine made of the grapes taken from the old vines and those that have been best cared for and most exposed to the sun is called the *Grand vin.* That made from vines less favorably situated and grapes of an inferior quality is called the first and second wine. After this quality is taken off the lees, the residue remaining in the vat is taken out and subjected to a very strong pressure for twenty-four hours or more, and the wine squeezed out is called press wine. The lees are then taken and put back into the vat and water thrown over them, and in about two weeks the resulting liquid is drawn off. It is calculated that about one-eighth as much of this will be obtained as the grapes made of good wine. It is called *bonne première piquette.* After it is drawn off more water is put upon the lees and a second edition of *piquette* is made. This is not considered so good as the first, and both are said to be consumed by the laborers in the vineyards. It may perhaps be worthy of remark that the authorities of Bordeaux solemnly inform us that after this second baptism the lees are taken out of the vat and it is carefully cleaned; its work for the season is done.

It must not be supposed that all, or even the greater part, of the wine that is shipped from Bordeaux is grown in the district, nor that the high-sounding labels that are found upon the bottles of the various shippers indicate even remotely the character of the beverage within. In fact it is a reasonably fair supposition that if any name is found upon a bottle of wine shipped from Bordeaux, that wine will not be found in the bottle. For instance, if we find a label marked Margaux or Pauillac, the wine will probably be a product of the Blaye or Libourne district. If it is marked Blaye, it will probably be mainly a Spanish wine. There are notable exceptions to this rule; for instance, in what are called "château bottlings." If a wine is shipped from France with the château marks—that is the private mark of the vineyard to which it belongs, on the corks—it is certain that it is the genuine product of that vineyard. It does not follow, however, that it is not a very bad wine. Instances are not unknown—it might almost be said not uncommon—in which vintages have been sold, with permission to put the vineyard marks on the corks, when the wine was so bad as to be utterly unworthy of its name. It is fair to say that such practices are considered by reputable growers and wine merchants exceedingly reprehensible. But the fact remains that a very large proportion of the wine shipped from Bordeaux is made up by blending the wine of the district with the various productions of Spain, Italy, Algiers, the south of France, and Germany, the moral of all which is, that if the buyer can not depend on his own taste the best course he can adopt is to seek out a trustworthy wine merchant and rely upon his honesty to get good value for his money.

Leaving the Médoc and proceeding to the southeast of Bordeaux,

we come to the Graves district. One of the vineyards numbered among the first growths, the Château-Haut-Brion, is found in this district, in the commune of Pessac, immediately south of Bordeaux. Among the better known growths of the Graves may be mentioned the Château-la-Mission, Haut-Brion, Château Pape-Clément, Château-Bellegrave, Château de Bouillac and Haut-Bailly. The southern part of the district is called the Petits Graves. The names of some of the communes of this district are often found, with more or less justice, on Bordeaux labels. Among these are Isle-Saint-Georges, Saint-Médard-d'Eyrous, Aïguemorte, Beautiran, Labréde, Virelade, Podensac, and Pujols.

Going on up the left bank of the Garonne we now come to the Sauternes, or white wine district, in which the principal growths are classified as follows:

GRAND FIRST GROWTH.

	Commune.
Château-Yquem	Sauternes.

FIRST GROWTHS.

	Commune.
Château-La-Tour-Blanche	Bommes.
Château-Peyraguey	Bommes.
Château-Vigneau	Bommes.
Château-Suduiraut	Preignac.
Château-Coutet	Barsac.
Château-Climens	Barsac.
Château-Bayle (Guiraud)	Sauternes.
Château-Rieussc	Fargues.
Château-Rabaut	Bommes.

SECOND GROWTHS.

	Commune.
Château-Myrat	Barsac.
Château-Doisy	Barsac.
Château-Peyxotto	Bommes.
Château-d'Arche	Sauternes.
Château-Filhot	Sauternes.
Château-Broustet-Nérac	Barsac.
Château-Caillou	Barsac.
Château-Suau	Barsac.
Château-Malle	Preignac.
Château-Romer	Preignac.
Château-Lamothe	Sauternes.

The prices of these wines vary enormously from year to year, as does also their quality. They bring from 800 to 5,000 francs per tun, according to the vintage. Château-Yquem usually sells at from 24 to 25 per cent more than the first growths. The second growths generally bring from 20 to 25 per cent less than the first, but there is no absolute regularity about these proportions, although in a general way they hold good. In 1858 the Château-Yquem sold for 6,000 francs per tun.

It does not follow because a vintage is good in the Médoc that it will be so in the white wine districts. Some years when the red wines are very good the white are very poor, and *vice versa.*

On the north bank of the Dordogne, the wines of the first class are those that go under the name of St. Emilionais. There are five communes, all of whose wines are known under this name. They comprise the parishes of St. Emilion, St. Martin-de-Mazerat, St. Christophe-des-Bardes, St. Laurent-des-Combes, St. Hippolyte, and St. Etienne-de-Lisse. These make up a hillside extending parallel to the Dordogne at a distance of from 6 to 8 miles from its bank. The district runs from east to west; it is between 15 and 16 miles long and has an average width of about 7 miles. It is

bounded on the east and south by the plain of the Dordogne, on the north by the little water course called the Barbanne, and on the west by a somewhat higher plain that runs on into the Libourne district. It is on this plain that the celebrated Pomerol wines are grown. The whole St. Emilionais covers about 7,700 acres of which about 5,000 are devoted to the cultivation of the vine. The wines of St. Emilion are held in high esteem, second only to the growths on the left bank of the Garonne. A well-known report of an inspector-general says:

St. Emilion is beyond doubt the best expression of the hillside wines (*vins de côtes*). It has body, a fine color, an agreeable life, generosity, and a bouquet quite peculiar to itself that is found particularly in the best portions of this distinguished district. The good wine of St. Emilion, after a year or two, ought to have a dark color, brilliant and velvety, and a peculiar stamp of bitterness that flatters the taste. It should also have body, which does not prevent it after awhile from growing very soft. After six months in bottle, it gains considerable in *finesse;* it reaches all its perfection in from ten to twenty years.

At present, however, owing to improved methods in the vineyards and in the fermenting rooms, these wines are often finished in less than 10 years, and often keep more than 20. They are now often bottle-ripe at 3 or 4 years, and finished at 6, 7, and 8. They are generally divided into three classes, called first, second, and third marks or growths: this classification is founded on the prices obtained by the different proprietors, and these depend, of course, on the situation and exposure of the vineyard, the choice of grapes, the care and skill given to cultivation, to the picking, to the making of the wine, to the manufacture and selection of the casks, and to the storage and handling of the wine in the cellar. The first growths bring, in good years, at the vintage, from 600 to 1,200 francs per tun; the second, from 500 to 950, and the third, from 300 to 600. After leaving the St. Emilionais, we come in succession to the Libournais, the Fronsadais, the Bourgeais, and the Blayais, all wines inferior to those already mentioned but superior to those of the rest of the world.

The peninsula between the Garonne and Dordogne, Entre-deux-Mers, produces very fine red and white wines, the red improving comparatively in quality as we approach Bordeaux. Among the growths of this district are Château-de-Mireport, Carbon-Blanc, Montferrand, Ambès, St. Vincent-de-Paul, Ambarès, St. Eulalie, St. Loubes, St. Sulpice-d'Izon, Montussan, Château-de-Choisy, Floriac, Bouliac, Salleboeuf, Camarsac, Château-Poujape, Camblanes, Château-Labory, Baurech, Lagoiran, Cadillac, St. Macaire, Saint-André-du-Bois, etc.

Before taking leave of the wines of Bordeaux, it may be worth mentioning that there are several pickings in the best vineyards of the white-wine district. The first one takes the best grapes, and the resulting wine is called *crême de tête;* the second, less sweet and

heavy, and having more alcohol and *finesse*, is called *vin de tête*. After a delay of some days at this point, the third picking takes place; this wine is called *centre*; there are four or five of these pickings, and after they are all finished what is left on the vines is put into the vats to make the *vin de queue*.

Let it not be understood that anything that has been said is intended to asperse or belittle the true wines of Bordeaux. The production of the district will not supply the demands of the world, and its merchants have displayed wonderful skill in making up the deficiency in the best way possible. They are always willing to supply their customers with the perfect vintages if the customers are willing to pay the price, and if the customers are not willing to pay the price, they do not deserve to drink the wine. Nature has exhausted her resources, and man has aided her with all the patient skill that only the French possess when a grand Lafite or Margaux is finished; and one who would taste it should be ready to give up his money gladly and bow his head in grateful respect when the butler whispers reverentially in his ear "*Château Lafite, soixante-quinze.*"

BURGUNDY WINES.

The district in which Burgundy wines are cultivated lies in the Departments of Yonne, Côte-d'Or, and Sâone-et-Loire, composing part of the ancient province of Burgundy. Going south from Dijon, on the railway leading to Lyons, we leave on the right a chain of hills lying on the arc of a circle reaching from Dijon to Chagny. This is the world-renowned Côte-d'Or, containing the vineyards of Romanée-Conti, Clos de Vougeot, Romanée la Tache, Chambertin, Richebourg, Musigny, Volnay, Nuits, etc. In the estimation of many good judges Burgundy is superior to Bordeaux. It possesses great delicacy, a charming bouquet, and a delicious flavor, and in its perfection I will defy any man to say that he has ever tasted a better wine.

To begin at the northern end of the district, the first important vineyard south of Dijon is the Chambertin, near Gévrey, about 5 miles from Dijon. It produces both red and white wine of the highest type, so good, indeed, that the best of it rarely gets out of France. This was the favorite wine of Napoleon Bonaparte. The annual yield of the vineyard is about 150 hogsheads of 58 gallons each. Among the other vineyards in this vicinity are situated Musigny, Chambolle, Clos Bernardon, and Violettes. Five miles farther to the south is the Clos de Vougeot, and a somewhat detailed account of this vineyard may be of sufficient interest to warrant perusal. Such is the esteem in which its product is held in France that when a body of troops passes it the commanding officer wheels them into line and brings them to a present. *A tout seigneur, tout honneur.*

About the year 1110 Hugues le Blanc, the Lord of Vergy, presented to the monks of Citeaux the land that now constitutes the Clos de Vougeot. It contains at present about 112 acres and produces an average yearly crop of about 300 hogsheads. In 1162 the Duke of Burgundy confirmed the gift, and in 1164 the Pope, Alexander III, took the property of the abbey under his protection, naming especially the cellar of Vougeot. In 1359 the Abbot of Citeaux sent 30 casks of Vougeot to Gregory XI, who promised to remember the gift, and four years afterward made the abbot a cardinal. During the residence of the popes in Avignon their wine was furnished to them by the monks of Citeaux, and to their fondness for it Petrarch ("Epist. Senil.," lib. VII.) ascribes their unwillingness to return to Rome. The property remained in the hands of the Church until the Revolution, when it was confiscated and sold, in 1791, together with some adjacent property, to M. Focard, for 1,140,600 francs. Foucard was succeeded in the ownership by MM. Tourton and Ravel, and then by M. Ouvrard, by whose grandchildren it was sold to M. Milon. In 1889, it was broken up and sold to eleven different purchasers, so that as the Clos de Vougeot, it has ceased to exist. The last of the monks who had charge of the cellars was Father Gobelet. When he was deposed he managed to retain some of the wine, and had some of it still in his cellar when he died in 1813. On one occasion when Bonaparte, on his return from Marengo, sent to him for wine for his own table, he bade the messenger return and tell his master that if he wanted Vougeot forty years old he must come to Gobelet's house and drink it; he never sold any. The old presses of the monks are still in use at the vineyards. The next locality below the Vougeot is Vosnes, where are the Romanée-Conti, Romanée St. Vivant, Richebourg, and La Tache. The Romanée-Conti was not formerly in the first rank, but in 1730 a German, named Cronamburg, married the heiress of the estate and introduced such improvements into the cultivation of the vines and the handling of the wines that the vineyard is now considered to produce the best wine in Burgundy. It contains about 5 acres. Continuing south, we next come to Nuits, about 15 miles from Dijon. In this locality are the St. Georges, about 15 acres, and Corton. Ten miles farther south we come to Beaune, and shortly afterward to Volnay, a wine with a delicate flavor resembling somewhat that of the raspberry, and Pommard. Next to these is Meursault, produced in the upper part of the vineyard of Santennot. In this neighborhood are grown the wines called in Burgundy *passe-tout-grain*, and the dry white wines with a slight sulphurous taste, Genevières, Goutte d'Or, and Perrières. Southwest of Meursault is the Montrachet, which is the queen of the white Burgundies. There are three qualities of this wine, known respectively as the *L'Ainé* Montrachet, *le Chevalier* Montrachet, and *le Bâtard* Montrachet.

The Chevalier vineyard is the highest and contains about 45 acres, L'Ainé has about 15, and the Bâtard about 30. These vineyards all have the same exposure, and are separated from each other only by the roads running between them; but the best sells for twice the price of the second, and three times as much as the third.

The vineyards of Chassagne-le-Haut and Chassagne-le-Bas lie about 10 miles to the southwest of Beaune. Sautenay, with the comparatively inferior vintages of Clos-Tavannes, Clos-Pitois, and Gravières, terminates the Côte-d'Or.

It is difficult for anyone who has not lived in Burgundy to comprehend the infinite number of shades of difference in her wines. The most delicate precautions in the vineyard, the press room, and the cellar must be combined with good weather, the best situation, and skillful selection of grapes to make her perfect wines.

When well made and properly cared for, the keeping properties of Burgundy are excellent. I tasted this summer a bottle of 1846 Beaune that had made two voyages to India, and that was in perfect condition.

The best Burgundies, called *têtes de cuvées*, are made from selected grapes, taken from the best localities and exposures. These wines, in good years, may fairly challenge any in the world for the first place in everything that goes to make up a good wine, including durability and power to bear travel. The next class, called *vins de primeur*, approach the first very closely. The greatest difference is in the bouquet. Then come, successively, *les bonnes cuvées, les cuvées rondes*, and the second and third *cuvées*, each being poorer than its predecessor. The grapes in general use are the Pineau, the Norien, the Gamay, the Chandenay, and the Chasselas. The larger the quantity produced by these the poorer the quality. The common red wines of the Côte-d'Or, made from a mixture of all the grapes, are called *passe-tout-grains*. The prices of the Côte-d'Or wines vary enormously, running from about 30 cents a gallon, for the poorest passe-tout-grains, up to $2 for the best Montrachet. A wine for which 1,200 francs has been paid at the vintage may sell for 300 in a year, and *vice versa*. The Hospital of Beaune, founded in 1443, derives its principal revenue from the sale of the wines made in the vineyards belonging to it in Beaune, Corton, Pommard, and Volnay. Its sale takes place on the first Sunday in November each year, after the first rackings, and is largely attended by the principal buyers of France, so that the sale of the *Hospices de Beaune* fixes, in a measure, the prices of the vintage.

Chablis is grown in the department of Yonne. It is hoped that no reader of this sketch will ever have for his sins to bear so heavy a burden as has the name of Chablis; there is hardly a white wine in the world that has not at some period of its career been pressed into the service and forced to enlist for the campaign under the ban-

ner or Chablis. It is, in good years, very white, and is said to be dry, diuretic, and to taste like a flint (*pierre à fusil*). The reader may infer that the imagination that invented the taste of a flint wouldn't have any trouble at all about diuretics, and he would probably be right. It is hardly worth while to enumerate any more of the vineyards of Burgundy, since when their products are offered for sale in this country it will be, beyond a reasonable doubt, under the name of some of the vineyards that have already been mentioned. What has already been said about the labels of Bordeaux wines, will apply with equal force to those of Burgundy, and the reader may again be warned that his only safety lies in securing the services of some friendly and *competent* wine merchant.

THE PASSE-TOUT-GRAINS AND THE ORDINARY WINES OF BURGUNDY.

The glorious names of the grand growths of Beaune, Pommard, Volnay, Nuits, Chambertin, etc., are universally known and appreciated to the utmost, as they deserve, but there is a class of Burgundy wines, not so well known and less admitted into foreign consumption, but which is worthy in every respect of being brought forward and becoming an article of constant and daily use wherever wine is drunk. We mean the Burgundian *vins ordinaires*, the cheap dinner wines, usually drunk in France with an admixture of water.

These wines have, in the first place, the merit of being more within the reach of modest purses than the first growths, which are costly luxuries, and their quality entitles them to a special place in the list of the cheap wines that are now grown nearly everywhere in the world where the climate and the soil permit the cultivation of the vine. Ordinary Burgundy, in common with French wines in general, possesses a perfect cleanliness of taste, and it has besides, without being heavy or heating, a sapidity and a freshness which make it an agreeable, healthful and refreshing beverage; these qualities, added to the body peculiar to its robust constitution, remind one, to a certain extent, of the grand growths.

In making a careful study of the wines of the district, we find a complete series ranging without a break from the cheapest up to the first growths.

Before describing the ordinary wines, properly so called, we should give a word to the *Passe-tout-grains*, which should be classed as "grand ordinary" or "little fine" wines, as they occupy a place between the grand wines and the ordinary.

The *Passe-tout-grains* are produced from vineyards planted with both the superior Pineau and the ordinary Gamays—the more Pineau there are in the vineyard, the more the wine will approach the class of "fine" wines. It is the mixture of the two sorts of grapes that gives this wine its name of *Passe-tout-grains* (including both sorts).

Nothing is better than a good *Passe-tout-grain* as an intermediate wine between the grand growths and the ordinary wines. It is the *grand ordinaire* of the tables of the rich, and the good *Extra* of the modest Burgundian home, being both a fine wine and an ordinary one, as it combines the virtues of both the Pineau, which give bouquet and elegance to the fine wines and the Gamays which produce the others. The former give it its delicacy and perfume, the latter its freshness and solidity. It is like a marriage between a nobleman and a peasant's daughter; the children of the union possess the fresh and sturdy health of the mother and the aristocratic grace and elegance of the father.

This wine is not scarce; it is grown all over the *côtes* (hills) of Beaune and Nuits. On the hills of Beaune, the Parish of Meursault deserves special mention for the extent of the vineyards devoted to the production of *Passe-tout-grains.* On the hills of Nuits, all the district between Aloxe, Corton, and Prémeaux, near Nuits, as well as the vineyards that stretch from Gèvrey-Chambertin to the gates of Dijon, are given up to the growth of this wine. It is highly esteemed in Burgundy, and the Burgundians eagerly seek to produce it in all localities where the soil and exposure would not suffice for the production of the grand wines.

The ordinary wines are divided into three classes, the *ordinaires* of the *côtes*, the *arrières-côtes* (upper hills), and the *plaine* (flat country). These wines do not possess the delicacy of the *Passe-tout-grains*, but they have in their stead body and strength, together with a fresh and agreeable fruity taste.

The *ordinaires* of the côtes are the best and the highest priced, and come in the scale of Burgundy wines immediately after the *Passe-tout-grains.* They are the product of the Gamay grapes gathered among the lower hills, and the best of them are made in the region of the *Passe-tout-grains.*

In the district called the *Côte de Beaune*, Corpeau, Puligny, and Meursault produce many Gamay wines; in the *Côte de Nuits*, Serrigny, Corgoloin, Comblanchien, and further north, in Perrey, Brochon, Fixin-Couchey, Marsannay, and Chenove excellent Gamay's abound. As these wines are produced in the *Côte de Beaune* or the *Côte de Nuits,* they are generally sold respectively as "Beaune" and "Nuits," which must be considered as abbreviations for *ordinaires* of the *Côte de Beaune* and *ordinaires* of the *Côte de Nuits.*

The *ordinaires* of the *Arrières-Côtes* possess the same characteristics as the *ordinaires* of the Côtes; but with less richness and less body. They are proportionally cheaper. They are excellent wines for habitual drinking, particularly in the good years, and an amateur who has grown accustomed to them will not use any other wine for his "*ordinaire.*" These wines are grown throughout the extent of the Arrières-Côtes. The most important localites are Villars-les-

Fontaines, Magny-les-Villers, Echevronne, in the *Côte de Nuits*, and Nantoux, Mandelot, Meloisey, St. Romain, Larochepot, and Nolay, in the *Côte de Beaune.*

The wines of the plains are weaker than those that we have mentioned, and have no interest for the export trade.

This short sketch of the cheaper wines of Burgundy may serve to show that in addition to the antique renown of her grand vintages, she may claim the modest merit of growing excellent ordinary wines, admirably fitted to bear transportation, and richly deserving the attention of foreign markets.

CHAMPAGNE.

Champagne—nobody exactly approves of champagne. Every old *roué* in the world "would rather have a bottle of good Cos d'Estournel or Pichon Longueville than a hogshead of it;" but everybody drinks it; it is the best-known wine in the world; to large classes of Americans "wine" means champagne. It is like those pretty, pert, young women, who are perpetually doing or saying something that is not exactly right, but who, do or say what they may, are always agreeable.

We are indebted for the invention of this wine to the ingenuity of Dom Perignon, the cellarman, in 1688, of the Benedictine monastery of Hautvillers, who conceived the idea of blending the various varieties of wine that he found in his cellars. He also was the first to adopt corks to stop the bottles. It was the boast of the Benedictines that they had given nine archbishops to Reims, and furnished a couple of dozen of abbots where they were needed. The abbots and the archbishops are dead and forgotten, and all their works, but the fame of Dom Perignon will never die, while the eye of beauty sparkles with his deathless wine as the corks go flashing on their merry way to the ceiling.

The vintage in Champagne is conducted with the greatest care. The must is first run into vats to clear, and when it begins to ferment it is transferred to casks of a capacity of about 58 gallons. About Christmas time the first racking takes place, and this should be done in dry and frosty weather. About four weeks afterward it is racked again and fined, and it should be racked again and fined again before it is bottled. After the first racking the *cuvée* is made; this operation consists in emptying the casks into large vats, holding from 10,000 to 15,000 gallons each; that is, from 50,000 to 75,000 bottles. It is in making the proper selections of the various vintages for this *cuvée* that the great art of the champagne-producer lies. The usual proportion is four-fifths of wine made from black grapes, and one-fifth of that from white. The Mountain of Reims is supposed to give bouquet; Avize, delicacy; Bouzy and Verzenay,

body and vinosity; Ay and Dizy softness and roundness; and the white grapes of Avize and Cramant, lightness and effervescence. As the fermentation is not yet finished, it will readily be seen that a good *cuvée* requires long experience and infinite skill. The wine is bottled in the following March or April, although sometimes this operation is deferred much later, on account of the weather or the slower development of the wine. The first cork is secured in such a way as to be easily removable, and the bottles are then placed in a horizontal position in stacks numbered and marked for identification. The breaking of the bottles that occurs at this time used to be enormous; a case is on record in which out of a *cuvée* of 6,000 bottles all were lost but 120. At present, owing to the improved strength of the bottles, the breakage is reduced to about 5 per cent. These bottles cost about 6 cents apiece. During this time the bottles are moved to greater depths in the enormous cellars of the district, or *vice versa*, as the fermentation proceeds more or less rapidly. They are are left in a horizontal position from eighteen months to three years, until the fermentation, in the opinion of the owner, is entirely finished, and the wine perfectly matured. By this time the sediment thrown off by the fermentation has collected on the lower side of the bottle, and in order to get it out it is necessary, in the first place, to get it down on the cork. This is accomplished by placing the bottles in racks with the cork inclined downward, where they are visited every day by a cellarman, who, by giving each bottle a sharp twist in the same direction, and at the same time increasing the inclination, causes the sediment, in the course of six weeks or two months, to roll down in a sort of a ball upon the cork. Great skill and experience are required in this operation, in order to get the sediment perfectly together. The best men can twist 50,000 bottles a day, or 70 a minute. It is customary at various times, in Champagne, for the workmen to wear wire masks to protect their features from flying bits of glass. The sediment being down on the cork, the wine is now ready for disgorging. This operation is performed by a skillful workman, who, holding the bottle neck downward, loosens the *agrafe* securing the cork, which flies out, carrying with it the ball of sediment. He then inserts a temporary cork and passes the bottle to another, who puts in the *dosage* and fills the bottle with wine from another bottle of the *cuvée* kept for the purpose. The bottle then goes to the corker, who passes it to the workman who puts on the wire, and the wine is then ready for shipment, although it is generally allowed to rest for some months, in order to permit the "dose" to amalgamate properly. Before the introduction of the "dose" the wine is *brut*, and is bitter and disagreeable. The dose gives it sweetness, and sometimes something more. It is varied to suit the taste of the country to which it is to be shipped.

There are imitations of champagne made in nearly all of the wine countries in the world, and various new processes, such as the Reihlen, etc., are always springing up, but none of these productions can be mistaken for the genuine wine by any one with a modicum of taste and smell. The importation of champagne into the United States in 1887 was 3,208,872 bottles, two pints being counted as one bottle. The quantity in the hands of the merchants of champagne, on April 1, 1888, was 75,218,074.

The following table shows the exportation of champagne since 1860:

Years.	Number of bottles (quarts) exported to foreign countries.	Years.	Number of bottles (quarts) exported to foreign countries.
1860-'61	8,488,223	1878-'79	14,844,181
1862-'63	7,937,836	1879-'80	16,524,593
1864-'65	9,101,441	1880-'81	18,220,980
1866-'67	10,283,886	1881-'82	17,671,366
1868-'69	12,810,194	1882-'83	17,612,821
1870-'71	7,544,323	1883-'84	18,206,956
1871-'72	17,001,124	1884-'85	18,189,256
1872-'73	18,917,779	1885-'86	14,923,490
1873-'74	18,106,310	1886-'87	16,222,903
1874-'75	15,318,345	1887-'88	17,257,685
1875-'76	16,705,719	1888-'89	18,904,469
1876-'77	15,882,964	1889-'90	19,148,382
1877-'78	15,711,651	1890-'91	21,699,111

The champagne vineyards, Reims, Châlons, Ay, Avize, Epernay, etc., cover an extent of 14,000 hectares, which have produced since 1863 the following crops:

Years.	Hectoliters.	Years.	Hectoliters.
1863	563,028	1878	540,843
1864	389,030	1879	96,308
1865	650,661	1880	110,148
1866	884,085	1881	664,870
1867	176,786	1882	320,844
1868	559,850	1883	411,430
1869	388,313	1884	524,013
1870	325,455	1885	372,685
1871	248,423	1886	296,609
1872	203,680	1887	473,149
1873	142,669	1888	210,450
1874	371,752	1889	277,727
1875	987,243	1890	253,348
1876	732,763	1891	161,285
1877	473,077		

The average of the last ten years is 330,158 hectoliters, or 41,269,750 quart bottles per annum.

Even in the poorest years the production of champagne is considerably greater than the consumption, and she has consequently always a large reserve (seldom less than 60,000,000 bottles) in her cellars.

MACON AND RHONE WINES.

The southern department of Burgundy, Saone-et-Loire, contains the Arrondissement of Macon, which produces some red wines that are widely known. They are somewhat coarse, of full body, in character between a Burgundy and Rhone wine, and are very agreeable and healthy table wines. They are generally to be had, at somewhat exhorbitant prices, in respectable eating houses and clubs in New York. They are at their best at 7 or 8 years of age. The white wine of Pouilly is, in good years, of most excellent quality. The Canton of Moulin-à-Vent grows a nice delicate, little red wine, but it has but little durability, being finished at 2 or 3 years, and never lasting beyond 10. The wines of Yonne, Auxerre, Haute-Perrière, Tonnerre, and Vauxdesir, and those of Saone-et-Loire, Thorins, Chenas, Fuissé, etc., are what the ordinary wine-drinker of the world is consuming; when he is proudly figuring to himself that his honored glass is brimming with Romanée-Conti, La Tache, and Montrachet. And he is lucky to get these.

After leaving Burgundy we come to the wines of Dauphiny, known now generally as Rhone wines. Among the best known of these are the Hermitage wines grown near Tain, in the Arrondissement of Valence, Drôme. The wine was originally cultivated by some hermits, the last of whom died about one-hundred and twenty-five years ago; the ruins of their ancient habitation may still be seen on the summit of the hill named Bessas. The Red Hermitage has the richest color of any French wine, and in good years sells as high as 550 francs the *pièce*, at the vintage. This is equivalent to about $2 a gallon. These vineyards have been sold at $6,000 an acre. The red wine will keep about 20 years. It is generally sold for consumption at from 4 to 5 years of age. White Hermitage is made entirely of white grapes. The quantity of the first quality does not exceed 7,000 gallons, and it is so highly esteemed by the French that, like the first growths of Burgundy, but little of it ever gets away from home. It has a rich taste, a straw-yellow color, and a bouquet peculiar to itself. Its fermentation often keeps up for two years, and it is never sold if it can be helped until this is complete. It keeps for a century, but after thirty years of age its perfume and taste change, and it loses some of its delicacy. Straw Hermitage is carefully made from selected grapes, dried on straw for six or eight weeks before being put into the press. It is a luscious wine, and brings enormous prices, as it can be made in perfection only in years that are suited to bring the grapes into the highest condition. There are two growths of Red Hermitage, and three of White. The

deficiency in the supply of this wine is made up by Crose, Murcurol, Chanos-Curson, etc.

BEAUJOLAIS, ROUSSILLON, ETC.

The Department of the Rhone, the old Lyonnais and Beaujolais, raises some fine wines. In the arrondissement of Lyons, the most noted is the Côte-Rôtie. It is a red wine of excellent color and body, and with a slight odor of violets. It is slightly bitter, and is much improved by age. St. Foy and Chassagny are grown in this district. From the arrondissement of Grenoble we have the white wine St. Péray. In Orange is grown the Châteauneuf du Pape.

Enormous quantities of red and white wines are made throughout the south of France. Some of them are of admirable quality, but it is more difficult for them to find their way through Cette and Montpellier, in a state of nature, than it was for the Lady Godiva to find hers through Coventry. The Montpellier district produces the St. George d'Orgues. Frontignac and Lunel are hardly known except to the wine merchants of the Hérault, by whom they are used in making up the various abominations called "port," "sherry," etc., that have given Cette its evil name.

The Pyrénées-Orientales, the Roussillon district, produce some 8,000,000 gallons of wine of varying quality. It is sold according to its strength in color, alcohol, sugar, etc. The grapes of the district are the Grenache, Muscadine, Mataro, Crignan, etc. The vintage is conducted somewhat as it is in Hungary, but there are only two pickings. The wines keep a long time, and it is reported on good authority that there is in the cellar of one of the growers of Roussillon a quantity of the vintage of 1659. Roussillon generally has a deep color. One quality is rich, strong, and full of bouquet; the other is lighter and less generous, and it is generally consumed at home. It is a favorite wine in the north of Europe, whither it often goes via Bordeaux. The Masdeu vineyard has been known to the English world for only a comparatively short period, although it was sold by the monks of St. Salvador in 1273. It once belonged to the Templars, and afterward to the Hospitallers. The wine is shipped from Port Vendres; it very much resembles port.

There are various other wines raised in France; in fact, there are only six out of her eighty-six departments that do not produce any wine. Those that have not been mentioned are, however, of little importance.

GERMAN WINES.

Next in importance to the wines of Bordeaux are those of Germany. The culture of the vine was introduced into Germany from France in the year 280 A. D. Wine-making in this country first grew into importance, however, during the reign of the Emperor

Charlemagne, who made various wise regulations for the improvement of the German vintage, the memory of which has been handed down in the annals of the Rhine in the proverb that tells us that every year, at the blooming, the great Emperor rises from his grave at Aix and blesses the vineyards along the Rhine. Geibel sings:

> "Bei Rüdesheim, da funkelt der Mond in's Wasser hinein,
> Und baut eine gold'ne Brücke wohl über'n grünen Rhein;
> Der Kaiser geht hinüber und schreitet langsam fort,
> Und segnet längs dem Strome die Reben an jedem Ort."

Under succeeding dynasties the culture of the vine in Germany was extended toward the north, and at the present time the wine-making part of the Empire comprises the following districts: The Rheingau, the Moselle region, including the valleys of the Saar and the Nahe; the Ahr, Rheinhesse, the Pfalz (Palatinate), the Haardt Mountain region, the Taunus, the Main, Baden, and Suabia and North Germany (Elbe, Posen, Saale, etc.)

The vine lands of Germany are the northernmost in the world, and probably receive the greatest care. The peasants all take a deep interest in the vineyards, and prefer to be employed in them rather than to accept other work at better wages.

The white German wines are the best. There are some growths of red wines that are not at all bad, that even have quite a reputation, but the fame of German vineyards may be said to rest entirely on the white wines. The best of these acquire, at about three or four years of age, a delightful bouquet, and a very pleasant taste; but as they grow older they lose more or less of both of these and get more body and strength. They are distinguished by their keeping qualities and their power to bear transportation, being excelled in this respect only by Madeira and fortified wines.

The best wines in Germany are grown in the Rheingau, which extends east and west about 25 miles along the right bank of the Rhine, from Lorch up to Walluf, and is about 8 miles in width. The district is composed of a chain of hills, parallel to the course of the river, the steeper hills being terraced to prevent the earth from giving way. There is much variety in the soil—clayey shale, marl, chalk, limestone, molasse, etc., all occurring in the district. The soil of the best vineyards consists of a hard gravelly clay and stones; the latter, by retaining the heat of the sun, improve the warmth of the ground. The poorest wine is made on a soft yellow clay, on which large crops are made nevertheless. The surrounding hills protecting it from all exposure save the southern, and the broad Rhine throwing up to it all the rays of the afternoon sun, the well-watered Rheingau, with its perfect soil, is the very paradise of the wine-growers, and many, many reams of paper have been consumed by German poets in singing its praises. The leading grape in the Rheingau is the Riesling; in addition there are found

the Sylvaner (Oesterreicher), Traminer, Weisselben (Kleinberger), black Clävner (Burgunder), and Ruländer. The production of the district runs at about from 2,000,000 to 2,500,000 gallons a year. The great growths naturally make up but a small proportion of this quantity. The best wines have a flavor and bouquet peculiar to themselves ; it is quite impossible to describe this aroma, but it is recognized immediately by the fortunate persons who are familiar with it when they enter a room where a bottle has been newly opened. No other wine in the world possesses this quality in the same perfection. As stimulants, particularly for the aged, they are probably to be preferred before all others. The principal places where they are sold are Rüdesheim, Eltville, Mainz, Frankfort-on-the-Main, and Cologne.

The wines of the Rheingau are usually classed as follows : First growths: Johannisberg, Steinberg, Rauenthal, Gräfenberg, Rüdesheim, Marcobrunn, and Assmannshausen. The last is a red wine. Second growths : Geisenheim (Kosakenberg, Rothenberg Morschberg, Katzenloch), Hattenheim, Dorf Johannisberg, Winkel (Hasensprung), and Vollrathsberg. Third growths : Erbach, Eltville, Eidingen, Kiedrich, Mittelheim, Oestrich, Schierstein, Walluf, Hallgarten, and Lorch. Lorch is also a red wine.

The Schloss-Johannisberger is usually admitted to be the best white wine in the world. The vineyard belongs to the Metternich estate, having been presented to the great Austrian chancellor in 1816 by the Emperor Francis. It lies near the middle of the Rheingau, between Geisenheim and Winkel, about three-quarters of a mile from the river, and consists of 65 acres, lying on a conical hill about 150 feet high. It was originally a Benedictine abbey, founded in A. D. 1106, by Ruthard, Bishop of Mainz. The present castle was built in the year 1717 by Prince Adalbert von Walderndorf. Of the 65 acres there are always from 42 to 45 under cultivation. Everything is naturally kept in perfect condition, and the vineyard may generally be regarded in all respects as a model for the wine-making world. It was formerly the practice to sell the "Cabinet" wine only in bottles, but of late years some of it has been sold in casks with the rest. The very best qualities are reserved by the proprietor for his own use, and for presentation to reigning monarchs. When the vintage does not come up to the standard of "Cabinet" wine, the wine is disposed of by public auction, the price varying from $1,200 to $3,000 per stück of 240 American gallons. In 1831 the best stück was sold for $6,400 ($5 a bottle). The average yearly production of the vineyard is about 7,200 gallons. All of the wine in the immediate vicinity of this vineyard is sold under the name of Dorf Johannisberger, and that made in the vineyards lying between the Schloss and Geisenheim (*die Kleine Klause*) is called Klaus Johannisberg, so that we have the "Cabinet," "Schloss,"

"Klaus," and "Dorf" Johannisberger. If the gentle reader never has to drink any worse wine than any of these, let him die happy.

Next in rank to the Johannisberg comes the Steinberg vineyard, formerly the property of the Duke of Nassau and now belonging to the King of Prussia, the present Emperor of Germany, containing some 80 acres, and lying about 3 miles from the river, between Hattenheim and Hallgarten. The Steinberger Cabinet is nearly equal to Johannisberger in quality, and brings nearly as good prices.

The province of Rheinhessen is contained within a triangle drawn between Worms, Mainz, and Bingen. The province is a rolling country with a few woods or meadows; the climate is soft and mild, and the exposure of the vineyards generally easterly and southeasterly. The annual production of wine is about 8,000,000 gallons. In good years the best localities produce wines almost equal to those of the Rheingau. The principal commercial place in the district is Mainz, where some 2,000,000 gallons are sold annually. This district produces only one wine that is classed as a first growth, namely, Liebfrauenmilch. This celebrated vineyard is situated at Worms, on the ruins of an old religious establishment, and contains about one and a half acre. By dividing the quantity of wine that can be produced on this extent of land by the whole quantity of Liebfrauenmilch consumed in the world, the reader will arrive at the proportion of the latter that may be considered genuine. There are some 13 acres in the immediate vicinity whose production is called Liebfrauenmilch, but it is not the real wine. The grape of this vineyard is the Riesling. In the year 1831, the 1828 Liebfrauenmilch was sold for $1,600 a stück. This wine has much character, great bouquet, and a soft and agreeable flavor, but it lacks body. The wines in Rheinhessen of the second class are: Niederingelheimer, Oberingelheimer (red), Scharlachberger, and Wormser; the latter are usually all sold as Liebfrauenmilch. In the third class stand Bingen, Laubenheim, Nierstein, and Oppenheim. In the fourth class, Alsheim, Bechtheim, Bodenheim, Büdesheim, Guntersblum, Mainz, Nackenheim, and Selzen.

The Pfalz district (the Bavarian Palatinate) is the one to which we are indebted for the largest quantity of good Rhine wine. The soil is more sandy than that on the right bank of the river, and is composed of sand interspersed with sandstone, and the loam mixed with shells of existing species known in the Rheinland as loess. A railway, cut sometime ago through one of the vineyards of the best part of the Pfalz, was compelled by the assessors to pay the owners some $5,200 per acre for the land. The cost of cultivation is estimated to average in the Pfalz from $28 to $35 per acre annually, and the net profit to the grower will average, taking the bad years with the good, from $32 to $48 per acre. The grapes are generally Traminer and Riesling. They were formerly grown together, but they

are gradually more and more separated, as the growers think they do better by themselves. The Orleans grape was formerly a favorite in the Palatinate, but it is more and more neglected of late years. The wine produced from it here is lacking in life, bouquet, and flavor, as compared with the product of the other two varieties. The Pfälzer wines are distinguished by a lack of acid and an excess of albuminous matter; they fill the mouth well, "roll over your tongue like oil," "like a yard of velvet," a quality known in German as *schmalzig*; our best equivalent is "oily." Even the middle and smaller grades, although they may be dry and somewhat hard, are less sour than those of Rheinhessen and the Moselle. These wines are particularly pleasant to drink while they are young, and during the last 50 years they have gained so many friends that they now make a strong competition in the market of the world with the great growths of the Rheingau. The best wines rarely sell for less than 600 florins at the vintage (about $1 a gallon), and the lower grades may be had as low as 100 florins. The Palatinate offers a remarkable example of the improvement that may be made in the culture of the vine, and in wine making, by rational scientific study and painstaking. From ordinary wines the quality of some of the vineyards was so much improved in about twenty-five years that their product sold as high as 5,000 florins ($8 a gallon). The first growths of the Palatinate stand little below those of the Rheingau in general estimation. The wines are nearly all white, although red wines of good character are made at Königsbach, and in the Annweiler and Bergzabern valleys. The usual classification is—first growths: Forst, Rupertsberg, Deidesheimer (all small Pfälzer wines generally go under this name in North Germany); Wachenheim, Dürkheim, Ungstein, Kalstadt. Second growths: Mussbach, Herxheim, Königsbach, Neustadt, and Gimmeldingen. Third growths: Hambach, Frankenthal, Burrweiler, Frankweiler, Gottramstein, Gräfenhausen, St. Martin, Maikammer and Dittesfeld.

The triangle between the Moselle, the Saar, and the Nahe is the next principal wine-producing district of Germany. The vineyards of the Moselle, "the bride of the Rhine," are the oldest in the empire. The Moselle wines are distinguished by a remarkably developed and pleasant bouquet, which causes them frequently to be preferred, particularly by foreigners, to the Rhine wines. It is particularly marked in grapes that have not had too much sun. The wines are delicate and full of spirit, but they have little body and will not keep any great length of time. The ordinary qualities in their natural condition are not worth shipping out of the district, and it was for their benefit that Dr. Gall invented his process of "improvement," which will be explained hereafter. The Moselle wines are classified—first growths: Brauneberg, Piesport (also red), Zeltingen, Oligsberg, Dusemont, and Berncastler-Doctor—this wine

is so named because on one occasion a noble knight, having been given up by his physicians, insisted upon finishing one more flagon before he put his angel garments on, and after having enjoyed it he recovered immediately, and led his doughty men in many a well-fought fray afterward:

> "Zapft an den ächten Doctorwein,
> Ihr kranken Brüder, schenkt euch ein,
> Der ist der beste Doctor!"

Second growths: Trier, Wehlen, Graach, Becherbach, Litzerhecken, Rütz, and Grünhausen.

The wines of the Saar are much of the same character as those of the Moselle, and are generally sold as Moselle wines. The best are the Scharzhofberger, Scharzberger, and Bockstein; in the second rank are found Klein-Blittersdorf, Niedaltorf, Uerzig, and others whose names are almost unknown to English-speaking people.

The production of the valley of the Nahe, when of sufficiently good quality, generally gets into business as Rhine wine; when it is not so good it is sold as Moselle wine. The principal vineyards are those of Kreuznach, Münster, Monzingen, Winzenheim, and Laubenheim. The last is frequently confused with the celebrated vineyard of the same name in Rheinhessen.

The wines raised in the valley of the Ahr are all red. They have a peculiar dark purple color, much sweetness and bouquet. Their flavor is agreeable and attractive, they have good body, and are soft to the taste, but their keeping qualities are poor, and they will not bear shipment. They are known collectively to the domestic wine trade as "Ahrbleicharte" or "Ahrbleicher." Some sparkling wines are made in Rhenish Prussia, that have some vogue in England under the name of Sparkling Wallporzheim.

The wines of the Lower Rhine are sometimes good, strong, fiery, and of good taste, and in former times the best of them were in as good demand as those of the Rheingau, but now they never rise above the third or fourth rank.

The Taunus Mountains, running northeast and southwest through the southern part of Nassau, produce on their slopes some excellent wine, notably that of Hochheim, which is usually classed as a Rheingauer. Its elder fame was so great that it gave a generic name to German wines, which are known among the English to this day as "Hock." But all the vineyards in the Taunusgebirge do not bring forth Hochheimer; as we go east from Wiesbaden toward Frankfurt the vintages become very much mixed, as runs the proverb:

> "Der Wein vom Rhein ist immer gut,
> Der Moselwein nicht schaden thut;
> Der Neckarwein ist auch noch recht—
> Frankfurter Wein ist immer schlecht."

Hochheim still holds its place among the best German wines, and many of its vineyards, Dom-Dechanei (Präsenz and Kirchenstück) Stein, Hölle, and Lattenberg are known and loved all over the world.

The remainder of the wines of Germany, grown in Baden, Suabia, and in the valley of the Main and the Neckar, and in North Germany, while they present many curious characteristics, and are worth study, are not of sufficient interest to occupy a place here.

The following table shows the quality of Bordeaux, Champagne, and German wines in each year since 1867:

Year.	Bordeaux.	Champagne.	German.
1868	Generally good	Fine	Good.
1869	Very fine	Superior	Ordinary.
1870	Varying	Very good	Fair, light.
1871	Elegant, thin	Ordinary	Inferior.
1872	Ordinary, fair	Ordinary, good	Middling.
1873	Bad	Middling	Fair.
1874	Fine	Very fine	Fine generally.
1875	Very good	Generally good	Inferior, light.
1876	Bad	Fair	Good.
1877	Well made, elegant	Fair	Inferior.
1878	Very fine, some exceptions	Good	Fair, light.
1879	Inferior	Below medium	Hard, bitter.
1880	Thin, poor	Good ordinary	Part good.
1881	Good, ripens slowly	Medium	Irregular.
1882	Bad, mildew	Ordinary	Thin, sour.
1883	Medium	Fair, some good	Good.
1884	Much good	Very great	Better than 1883.
1885	Inferior	Good ordinary	Middling.
1886	Very bad	Ordinary	Fine, best since 1868.
1887	Good	Bad, mildew	Medium, small.
1888	Generally good	Poor	Poor to fair.
1889	Very good	Fair	Fair.
1890	Very fair	Good	Middling.
1891	Good	Good	Miserable.

HUNGARIAN WINES.

Perhaps after German wines those of Hungary occupy a larger place in the imagination of the world than any others. "*Nullum vinum nisi Hungaricum,*" cries the inspired Magyar when the golden vintage of the Hegyallja sparkles in the glass before him, and the agile gypsies are playing in tune the Rackoczy march. There seems to be a glamour that surrounds these Eastern vintages that bewilders those who approach them, and makes them a convenient tool for the rascals who pray upon the inexhaustible credulity of mankind. Whether there is anything in them to justify all the talk that has been made about them will be easier to determine as we go on.

Hungary still contains a superabundance of productive vineyards, and although the time has gone by when, for the half of a wagon load of empty casks, the Carpathian might have the other half filled with the best wine of the district, the quantity produced is still far beyond the home demand. It should be said, also, that some of the poorest wines on earth are brought to light by the Magyar peasants, in whose hands the vineyards chiefly are.

The Tokay, which takes its name from the town of that name, is, properly speaking, the wine of the district extending from 25 to 30 miles northwest from that place. This is known as the Hegyallja or Submontine district. It is a spur of the Carpathians, and contains about 14 square miles, of which about five produce the real Tokay.

The first Hungarian vineyards were planted by the Emperor Probus, and the Tokay wines were known as far back as the fifteenth century; but they did not come into vogue till about the year 1650, as it was not until that date that the present mode of manufacture was adopted. The soil of the Hungarian vineyards is all more or less volcanic; that on which the best wines grow is made of black trap, or decomposed porphyry, porcelain clay, and feldspar in other forms. Several species of grapes are cultivated, the principal being Formint (Mosler), Hars Sevely, Sar Feher (Honigtraube), and Forko (Lämmerschwanz); they are generally white, ripen early, and yield a large proportion of saccharine material. When they are first planted they are cut down at a knob within a few inches of the ground, and the superfluous young shoots are pruned at the same place every spring. In consequence, the knob swells and frequently becomes very large. These plants are known as "knob-vines." In order that the fruit may attain the fullest ripeness the vintage is put off as long as possible, seldom beginning before the end of October or the beginning of November, by which time, in favorable seasons, a considerable number of the grapes have become shriveled and half-dried. These are called *trockenbeeren*, or dry grapes, being chiefly supplied by vines pruned at the knobs, as just spoken of, and as it is on these grapes that the luscious qualities of the Tokay wines depend they are carefully separated from the rest. When a sufficient quantity has been collected they are put into a cask, the bottom of which is perforated with small holes, and the juice that exudes from them without any more pressure than is supplied by their own weight is the sirupy liquid known as Tokay Essence (Aszu)—"certainly the most fragrant, the noblest, the sweetest, the most spiritful, the best flavored wine in the world."

The wines known under the generic name of Tokay are the most celebrated dessert wines of the world, and like Johannisberger, known to every man, even although he has never tasted them and has seen only the frightful raisin brew that is everywhere sold under that name. The best varieties, which are grown in some 21 different lo-

calities, produce an average annual crop of about four million gallons; the best come from the Tarczal district, where the choicest wine is found upon a spot of ground some six hundred or seven hundred feet in length; it is called *Mezes-Male* (stream of honey), and, it is hardly necessary to say, never comes into the market; the others in this category are Talya, Mad, Lisska, Kissfaludy, and Zsadany. In the second-class stand the vineyards of Tokay (from which the wines take their name) and those of a number of other places whose Magyar names are quite unknown in the western hemisphere, and still farther afield there are other vineyards that produce in all some two million five hundred thousand gallons of wine in a year, not indeed of the quality of those that have been mentioned, but still bearing with some justice the name of Tokay-Hegyallja.

Tokay is divided into five varieties: (1) *Ordinari*, the lowest grade, from which the *trockenbeeren* have been taken out. (2) *Szmorodny* (natural), made from the grapes as they run without removing the *trockenbeeren*, a little sweeter than the *ordinari*, heavy-bodied, fiery, with a pleasant taste that the *connoisseurs* of Hungary prefer to any other of their vintages. (3) Masslacz, made by the addition of 1, 2, 3, or 4 butts of *trockenbeeren* to each cask of 10 butts; this is a sweet, soft wine, containing a large percentage of alcohol. (4) *Ausbruch.* This name is given to the wine when it has had added to it 5 or more butts of *trockenbeeren.* (5) *Aszu.* The essence, whose manufacture has been described. Alas! that the opportunity to taste it is not often given to ordinary mortals. Pius IV recognized its merits in 1562, when he said of the Talya "*Summum pontificem talia vina decent.*" Much therapeutic virtue is ascribed to Tokay, which is attributed to the quantity of phosphorus in it. Opinions in this matter, as well as in others relating to the qualities of this wine, are by no means unanimous. Townson, a competent critic, says: "It is, no doubt, a fine wine; but, I think, noways adequate to its price. There are few Englishmen, except on account of its scarceness, who would not prefer to it good claret or Burgundy, which do not cost one-fourth of the price. Some of the sweetish Spanish wines, begging its pardon, are, in my opinion, equally good, and, unless it be very old, it is too sweet for our palate." Shaw says: "The idea prevails that it is a wine of transcendently high quality, but a little practical experience would disabuse those who have this impression. On the contrary, it is coarse, sweet, and disagreeable, yet possessing qualities which cause it to be sought for by certain classes."

Genuine Tokay can not be bought in Austria for less than $4 for a bottle that holds not more than a pint. In 1860 Napoleon III paid 10,000 francs for 200 of these bottles, filled with the vintage of 1811. The Emperor of Austria sent the King of Holland 2,000 bottles, for which he had paid 7 ducats ($16.50) apiece. The whole district

covers an area of about 24 English square miles. As it is generally supposed that Tokay, like most of the mysterious things in Eastern Europe, belongs to Prince Metternich, it may be well to state that Prince Metternich never owned a foot of ground in this district, nor anywhere else in Hungary. According to Hungarian law, up to 1848, no foreigner could hold land in the Kingdom (and in this respect Austrians were considered aliens) except by obtaining the *indigenat* (naturalization) by special act of Parliament. The great diplomatist never asked for this privilege, never was inscribed on the roll of the Hungarian nobility, and never held any property in Hungary. Neither has the Emperor of Austria any property in Tokay, although as King of Hungary, of course, all the crown lands belong to the successor of St. Stephen, and thus he owns two vineyards in Tokay. But, as with all crown lands, these two vineyards are among the worst managed in that district, and the wine they produce is very indifferent. The boastful title of "Imperial Tokay" has no sounder foundation upon which to rest than the imagination of the salesman who invented it.

Although the law of entail was in force up to 1848, there is little land anywhere more democratically parceled out than the vinelands of Tokay. Most magnates make it a point to acquire some acres in the district, partly in order to have some of the wine from their own estates, and partly to have a place of their own to visit during the vintage, which is a time of general rejoicing and merrymaking. Many of these proprietors expend annually in festivities ten times the value of their crop.

This multiplicity of owners, most of whom retain their wine for their own use, makes it, as has been said, very scarce and keeps it at a very high price. What gets into the channels of commerce is mostly used as medicine, as people generally are not disposed to pay for very good wine until they have got themselves into a condition in which they can no longer enjoy it. The "phosphorus" in it will probably keep it floating on the top wave of popularity for a long time; the crafty wine-merchant, handing his medical friend a bottle of middling Somlauer, marked "Imperial Tokay," will warn him with a solemn wink not to drink it when his wife is out of town, and the English will long continue to say, "But the gray-headed roués on the Continent will have it, and would swallow it were it as bitter as wormwood. This may account for the raptures of some poets about it, and may also explain its popularity at a certain period at court here." It is said that the Tokay of "that wretched old debauchee," the Duke of Queensberry, fetched, when he died, a hundred guineas a dozen.

The Tokay wines, when new, are of a brownish yellow color, and exhale a peculiar odor that has been compared to that of *pumpernickel* (a kind of German bread made of unbolted rye). When they

get very old the color changes to greenish. As a rule, they are very lasting, and in Krakau, where the chief store of them is kept, they are said to have vintages a century old. The old wine is called *vino vitravno;* the newer, *vino slotki.* Eight ducats ($18.80) has been paid for the *vino vitravno.* This is equivalent to $358.20 for one dozen quarts.

In the next rank to those of the Hegyallja stand the wines of the Menes-Magyarat, from the Comitat of Arad, which in fourteen localities produces something like 3,500,000 gallons a year. These wines are made in the same way as Tokay, and produce a good, strong, white and red Ausbruch and table wine. The third growth is the Russter, in the Comitat of Oedenburg—a white, strong, sweet, aromatic Ausbruch and table wine, made in some nineteen places, to the quantity of about 1,000,000 gallons yearly. These Russter wines are the ones principally known to the export trade, particularly the English. The vintage occurs very late, often not till December. The vineyards are low-lying, close to the Lake of Neusiedel, near the Hungarian frontier, from 50 to 75 miles southeast of Vienna. These three complete the list of Hungarian wines of the first class.

In the second class we have white wines—Somlauer, Badacsonyer, Nesmelyer, Ermekeller, Ofner, Szerednyer, Neogradner, and Krassoer; red wines—Erlau-Visonta (known as Schiller and Rubinette), Szegzardi, Villaner, and Krassoer; all good, strong, well-bodied wines, and some of them possessing much flavor and bouquet. Szegzardi is noted for a sweet smell of honey.

In the third class the best known are Baranyaer, Pesther Steinbruch, Honter, Pressburger, Bagh-Ujhelyer, Weissenburger, Somogyer, Bakatorer, Eisenburger, Raaber, Balaton-Füreder, Erdöder, Fünfkirchner, Misslaer, Oedenburger, Paulitscher, Neusiedler, and Simonthurner. This list might be much extended, but as it is given it includes all Hungarian wines of any importance to the consumer.

The smaller wines of Hungary, not having as yet been much affected by foreign demand, are to be bought at the vineyards at very low prices. Excellent table wine can be bought at from 15 to 25 cents a gallon, and better qualities from 35 to 60.

In Southern Hungary the Banat and Voivodina produce some 30,000,000 gallons of wine per annnm. This varies in quality from a hard, coarse article up to very respectable wine of the second class. It is probable that the Hungarian wine drinkers of England and America are much more familiar with it than they suspect. In the southern portion of the Banat the practice of applying heat to increase the strength of the wines is quite common. The cooked wines (*vini cotti*) are called Wermuth, probably on account of their bitterness, as it is not the practice to add wormwood to them in Hungary. The most celebrated of these is the Karlowitz, made in

Syrmia; it is called Tropfenwermuth, because it is served in minute glasses of a peculiar form. The Karlowitz *Ausbruch* is almost as highly esteemed as the Tokay, and sells in good years for very high prices. When the wines are evaporated to a higher degree of consistency they are called *Senf*. This wine is largely manufactured in Versecs. The Banat is a paradise of fruit and wine. The imperial vineyardist, Probus, is buried there, and volumes could be written of its climate, its rivers, its people, and its legends.

ITALIAN WINES.

Whether it is owing to the character of the Italian people or to the climate, the fact remains that Italy produces but little good wine, and none of the first class. The methods of cultivation of the vine, the pressing of the grape, and the fermentation and the care of the wine in the cellar are all careless and bad. Time may improve all of these, but for the present the wines of Italy are made up of two classes; one, more or less meritorious, to be consumed at home by those who can not get anything better, and the other to be sold to Cette and places of that character, where its good qualities can be utilized and its bad ones neutralized. The descriptions we get are generally quoted from Italian poets, whose verse is far smoother than the wine they celebrate. In the north of Italy the best wines come from the neighborhood of Asti, which has given its name generally to the Piedmontese growths. The best of these are called Barolo, and are red wines made from the Nebiolo grape. They resemble in alcoholic strength and flavor the Rhone wines. The wines of Venetia are of no importance; the best are perhaps Mogliano, Vicenza, and Conegliano. In Tuscany we have Chianti and Pomino, Artimino and Carmignano, Verdea, which Frederick the Great was very fond of—but it isn't probable that he knew much about wine—and Montepulciano.

To those who have, like Aytoun's hero,

> ——"regal Montepulciano
> Drained beneath its native rock,"

it always seems to preserve a glamour of great goodness, and they are ready to sing with Redi:

> "Montepulciano d'ogni vino e il Rè!"

but it is necessary to go there to drink it, and the same may be said of Chianti, both white and red, for, owing to defects of manufacture, they do not bear transportation well. The best of these wines are the Chiantis of Broglio, near Siena, for which reason wine dealers generally call all Tuscan wines "Chianti." Bishop Johann Fugger is said to have found at Montefiascone a vintage of the Campagna Vino dell' Est, that was so good that he deliberately drank himself to death with it; but he must have been very tired of life. At the head of

the South Italian wines stands the famous Neapolitan Lacryma Christi, which is grown on the loose volcanic soil of Vesuvius, and is a luscious, sweet wine, yet somewhat quick on the tongue, and one that can not fail, when tasted in its perfection by the light of the volcano, to leave a pleasant memory. It is generally of a frank red color, but is made white as well, and some ill-advised sons of the mountain have even gone so far as to construct a sparkling wine from it. Capri produces a pleasant, pale yellow, subacid, fragrant little wine, and other small growths of fairish bouquet and flavor are found on the islands in the bay and around Lake Averno. The wines of Bari, Gallipoli, and Taranto are among the best known of the vintages of Naples. The Zucco, from the estate of the Duc d'Aumale at Cosenza, has a good reputation. Sicily produces a large quantity of wine known to commerce as Marsala, Sicily "Maderia," "Malmsey," etc., and Sardinia sends to Genoa some vintages of high alcoholic strength and some light wines a little like Riesling. The annual wine production of Italy is about 1,000,000,000 gallons. Most of it is consumed at home.

SPANISH WINES.

Pretty much all that has been said about the manufacture of Italian wines will apply equally well to the vintages of Spain. Nature has done all she could for Spain, but, therefore perhaps, man has done nothing to second her efforts. With the exception of what the English have accomplished in Andalusia, the methods of making wine and handling it are in Spain about as bad as they can be. The soil is generally good, being chalky and oölitic, and leaves little to be desired by the vineyardist. The glorious mountains lay at his feet all the treasures of exposure and shelter that soul can ask, the sun woos him every day, and the soft climate alternates in smiles and tears, pleading with him to make good wine; but he heeds not, and so we have the wines of Spain, full of body and force and fire and color, and with a sweet smell of their own—everything that nature can give—but lacking in finish, in delicacy, in roundness, and all that art and care ought to supply.

The center of the vine-growing district of the north of Spain is at Haro, in the northeastern part of Old Castile. It lies in the modern province of Logrono, but the district is known to its inhabitants as the Rioja, from the Oja, one of the tributaries of the Ebro, by which it is watered, and its wines as Rioja wines. This district has been but little known to foreigners until within a quite recent date. The enterprising merchants of Bordeaux have known its virtues longer, but it has not been familiar to the wine trade of this country for more than nine or ten years. Some effort has been made in the Rioja to improve the methods in the vineyards, and some

Cabernet-Sauvignon, Verdot, and Malbec vines have been planted. The results have been felt in a marked degree, and the wines readily command a much better price than do the corresponding grades in Aragon and Catalonia. The district produces some 26,000,000 gallons of wine, nearly all of which is red, and under the guidance of some industrious Frenchmen efforts have been made during the past five years to find a market for Rioja wines as such. This effort has met with but moderate success. It deserves a better fate.

Aragon makes some good wines in the mountainous district lying between it and New Castile. The best are the Cariñena and a *vino tinto*. The Ebro district produces some wines that are liked by the natives, and one called Ojo de Gallo (Cock's Eye), on account of the brilliancy of its color, is very highly prized by them. Biscay produces a large quantity of a harsh wine called Chacoli.

In Catalonia the inhabitants are so much attached to vine-growing that it is with difficulty that they can be induced to engage in any other agricultural pursuit. In some instances they plant vines in places to which they have to be let down by ropes. The production of the district in good years is about 75,000,000 gallons; but for the reasons that have been given the wines are generally very bad. They are shipped to Cette and other ports, and cunningly treated with alcohol and elderberries, and then shipped to England and sold for "Port" wine. Sometimes these things are done to them in Tarragona and Barcelona, and then they often come to America and are sold as "Burgundy Port" or "Tarragona Port."

From Valencia comes the Benicarlo, a powerful, deep-colored wine, held in some estimation among wine merchants, particularly in Bordeaux, where it is much used in blending with light wines to give them strength and color. Benicarlo takes its name from the little place on the Mediterranean coast, north of Valencia, whence it is shipped. The Priorato, so called because the original vineyard belonged to a Valencian priory, is a better wine than is generally grown in Spain. It is sweet, full of spirit, soft, of a good, delicate color, and has a slight bouquet. The wines of Alicante used to occupy a foremost position in the commerce of the world, but the curse of Spain rests on the place, and its business has died out. The *vino tinto*, made in the vicinity, is a deep red, strong, sweet wine, said among the natives to possess some antiseptic virtue.

In Granada, as in the Catalan country, the whole land is clothed with vines, and the mountain wines of Malaga have long enjoyed a reputation among foreigners. The favorite species of grape in Granada is the Pedro Jimenez. It is used in combination with other grapes in all the wines of the country, and by itself makes a powerful, sweet wine of some quality when old. The best wines of Granada are white. They attain great age. A small quantity of

the vintage of 1783 has recently been offered for sale at $3 a bottle. As high as $10 a gallon has been paid for very old Malaga. This wine sold new in 1733 at 50 cents, or say three times the price that sound wines are selling at to-day in Aragon and Catalonia. The wine called "Bastard" by old English writers was a sweet wine made in Granada from the Bastardo grape. It is quite customary here to flavor wines for home consumption with various kinds of fruits. This may be said to furnish a fruitful commentary on the bouquet of these wines; the Guindas is flavored with cherries; another with roasted pears, whence they say: "*El vino de las peras dalo a quien bien quieras.*" Malaga, commonly so called, has sometimes a peculiar flavor given to it by the admixture of some wine that has been slightly burnt in the boiling through carelessness. This will be more particularly described in treating of the *arrope* of San Lucar de Borrameda under the head of Sherry.

In Andalusia, on the right bank of the Gaudalquiver, there is made a light wine called Moguer, which is generally fortified and sold for sherry. At Rota, opposite Cadiz, they make a sweet, red wine carrying about 13 per cent of alcohol, called Tintilla, or Tinto di Rota—the English call it Tent. This grape, tintilla, is an exception to the rule among grapes; it is colored all through and could not make a white wine.

La Mancha produces a large quantity of wine. It is to this province that we are indebted for the Val de Peñas, or Manzanares. This is a red wine of good body, and a good vintage at the proper age is considered by some judges the equal of any red wine in the world. As its name indicates, it is grown on a rocky or stony soil. It sells at from 7 to 10 reals the arroba (from 25 to 30 cents a gallon) in the town of Val de Peñas. In the hands of French or German growers this wine would soon have a reputation equal to the growths of the Médoc or Rheingau.

Considerable quantities of wine are made in the Balearic Islands and sold in Cette, and the Canaries also produce largely. Up to the middle of the eighteenth century Canary, drunk as such, was a favorite wine in England; but its renown is now lost, and it is hardly known under its own name. To the antiquary Canary is a subject of great interest, but to the consumer of the present time it offers little worthy of his attention. The total annual wine production of Spain is about 900,000,000 gallons.

SHERRY.

An exhaustive account of this wine would fill a good-sized library, and the wine is not worth it. The district in which sherry wine, properly so called, is made is contained within the triangle at the three angles of which lie San Lucar de Borrameda, Jerez-de-la-Frontera, and Puerto de Santa Maria. This triangle contains about 75 square miles. As has been stated, the presence of foreigners in this

district has forced the natives to fairer work, and there is consequently a notable superiority in the Jerez district over the rest of Spain in methods of cultivation and treatment of the wine. The grapes are left on the vines until they are beginning to dry, and are sometimes exposed to the sun on mats for a day or two after they are gathered. They are turned and sorted carefully for the better wines. The soil is partly calcareous (*albarizas*), partly sandy (*arenas*), and partly clayey (*burros*). The *albarizas* produce the best quality, and the *arenas* the largest quantity. Before pressing, the grapes are sprinkled with gypsum. This custom, which obtains generally throughout Spain, is as old as the time of Falstaff. The wine is left in the fermenting tubs until the following March, when it is racked off. The grapes used are white, and, in general, mostly of the Pedro Ximenes variety. Sherry acquires a dark color only by age; but, where fashion requires it before nature is ready, it is colored by the *vino de color*, or *arrope*, as it is called. This is made at San Lucar de Borrameda, by boiling down a quantity of must to one-sixth of its original volume. This process is very carefully conducted over a gentle fire, and when it is finished the *arrope* is allowed to cool very slowly. In order to make "Amontillado," the grapes are picked two or three weeks earlier. The wine is, of course, drier, but the production of Amontillado is accidental, and sometimes out of hundreds of butts only a few "Amontillado" will be found. Between San Lucar and Jerez the Manzanillas are grown. They take their name from the resemblance of their flavor to that of the Camomile (*Anthemis nobilis*). The wines of Montilla, formerly very celebrated, are supposed to develop the Amontillado flavor better than any others, and it is from them that it takes its name. The Montillas are rarely found in commerce; their owners find them more valuable for use at home in the soleras. The soleras (foundation) are the stocks of old wines kept by the shippers of Jerez. When one of them receives an order, or wants to barrel a quantity of wine for transportation, he selects from his soleras such a quantity of each as in his judgment will make a wine, or blend, of the desired color and flavor. They are filled up from time to time in order to keep them uniform. As may easily be imagined, when it is remembered that the annual consumption of "sherry" in England alone has sometimes been twice as much as the production of the Jerez district, the probabilities of the consumer's getting a pure wine are extremely small. None of these wines are shipped without the addition of some brandy, although it could be done. It is not meant that there are not honest, high-minded merchants in Jerez, but when once mixing has commenced, *facilis descensus Averni*. Sherries have recently been sold in New York at $12 a bottle, and they were worth the money; but they were the result of three-fourths of a century's painstaking, conscientious work, and it may be laid down as a maxim that it is very hard work to get the worth of your money in sherry.

PORT WINE.

The Douro region, in which are grown the vines that make up that portion of port wine that is composed of wine, lies on the slopes of the mountains along the river Douro for about 60 miles above Oporto. The best part of it is on the banks of a tributary called the Corgo. The natural wines made in this country are excellent, but they are not the port wine of commerce. This is made by adding brandy during the process of fermentation, again at the racking, and more before shipping, to say nothing of Geropiga, so that the "wine," when it lands on a foreign shore, contains from 20 to 25 per cent of alcohol (whisky contains 50). It is then shipped, at from 6 to 12 months of age, to England (where, until recently, it was the favorite wine of the better classes), whose consumption has frequently been twice the production of the district. Geropiga is made by adding 50 or 60 pounds of dried elderberries and an equal quantity of brown sugar and molasses to 80 gallons of deep-colored must, and 40 gallons of high-proof brandy. It is difficult to conceive how a nation could be so lacking in sensibility as to consume the enormous quantities of this compound that were taken down in England. Some attempts have recently been made to ship the natural wines of the Douro, but as yet very few have come to America.

Some wines of inferior quality are made in other parts of Portugal. Those of Lisbon, like Canary, formerly had a wide reputation, but at present they are little known out of the wine trade, and do not get into consumption under their own names. The production of the Douro district is about 14,000,000 gallons, and that of the remainder of the kingdom about 125,000,000.

MADEIRA WINE.

Shortly after the discovery of Madeira, about 1419, the Portuguese settlers on the beautiful island planted the clearings with vines, and in the course of 200 years the wines of Madeira were known to the whole world. They were exported from the island some 35 years before America was discovered. Madeira occupies one of the most favorable positions in the world for fruit growing, lying in 32° north latitude, and about 16° west from Greenwich, with a delightfully equable climate, regular seasons, and freedom from storms. Its light volcanic soil—the island being of volcanic origin—fits it peculiarly for the culture of the grape. The first vineyards were planted on the south side of the island, and it is from them that the best wines have always come. The white grapes generally used are the Malvasia, Vidogna, Bagonal, Sercial (or Escanagao), Muscatel, Alicante, and Verdelho; and the red, the Bastardo, Negramollo, and Ferral. The latter is a table grape, and, like all grapes that are particularly good to eat, produces but an inferior kind of wine. In

preparing the casks in which the wine is to be fermented, it is customary in Madeira to put into them a small quantity (about forty-five hundredths of 1 per cent) of brandy; an equal quantity is added at the first racking, and twice as much at the second, making in all a little more than 1½ per cent. Sometimes another small quantity (less than 1 per cent) is again added before shipping. The principal varieties of wine made in Madeira are called Malmsey, Boal, Sercial, and Tinto. The Sercial is made of a grape grown from some transplanted cuttings of Riesling. The Malmsey is made of the Malvasia grape, and a volume could be written only to describe and enumerate the songs and legends in the English language about Malmsey and Malvoisie. The Jesuits once held a monopoly of it. The whole average crop of the island is between 2,000,000 and 3,000,000 gallons. About the middle of the present century the vines were attacked by a disease like oïdium, a cryptogamic growth, and the production was gradually cut down until in 1857 the entire crop of the island did not exceed 500 gallons. After that time the vineyards grew up again, and we are now beginning to receive again wines that are worthy of the attention of the lover of old Madeiras. It is said that Madeira can never be too old, or, as the high priests of the wine trade say, "We have never found any yet that was too old." It is hoped that the taste and perfume of old Madeira are familiar to all the readers of this work, and the writer can only urge upon them, if they have any of better date than 1850, to stick to it closer than a brother, for Madeira of the south side is like the sibyl's books: every time a bottle goes, it enhances the price of those that are left. Within a few years 1836 Sercial has been offered at $4 a bottle, and 1830 Boal at $3, and from that up to $12, and $15 has been cheerfully paid here. Madeira should be matured at home, or at least in an equally warm climate. It was formerly customary to send it to the Indies for a voyage or two, and this was very good practice, the constant movement aiding the heat in accelerating the maturing of the wine. It is now quite usual to subject the young wines at home to artificial heat and motion, in order to overcome their harshness as rapidly as possible, and to give them the mellowness and bouquet that in their perfection are imparted to wine only by age. The importation of brandy into Madeira is forbidden by law, a very good arrangement, as it causes the poor grapes, that would otherwise be made into poor wine, to be consumed in the distillation of brandy. The new wines, younger than 1860, can be had at very reasonable prices, and some of them are of excellent quality; but it must always be remembered that there are a great many very poor wines made in Madeira, and one of the most painful experiences good-natured men have to undergo is the bottle of the elderly naval officer from the pipe he divided with his shipmates when the *Bellerophon* lay at Funchal in the summer of 1870. The Tinto is not much exported; when new it

is something like Burgundy, and should be consumed at that time, because, when it gets three years old it loses both quality and color and does not last much more than 4 or 5 years. A very fine natural wine is made in Madeira, without the admixture of any brandy, but it has never become an article of export, and would probably not bear transportation.

AMERICAN WINES.

Wines have been made in America ever since the first intrusion of European settlers into the country. In California, as in many countries of the world, it was to the good priests of the Catholic Church that we owed the earliest vineyards. Vineyards have been cultivated and wine made in this and other regions of the United States, such as Pennsylvania and Virginia, ever since, that is to say for a continuous period of four centuries. In other localities, such as Massachusetts (Martha's Vineyard), etc., the manufacture of wine having under the existing climatic conditions been found unprofitable, has been abondoned. The earliest plantations of the vine in California, being made by Spaniards, were naturally from Spanish seeds and cuttings, and owing to the proximity of the vineyards to the mission houses of the priests, these Malaga varieties came to be called the Mission grape. The European grower will recall many similar instances in which the recognition of the fostering care of the church has baptized the production, *e. g.*, Priorato, Hermitage, etc.

A very large proportion of the production of California, say two-thirds, continues to be made from the Mission grape, which furnishes a wine rich in alcohol, without bouquet and with little flavor aside from a strong earthy taste, a type toward which all imported varieties tend to return.

In other portions of the United States the most successful growers devote their principal attention to indigenous varieties, Cordifolia, Riparia, Aestivalis, Labrusca, etc., producing wines with a strong muscatel flavor and bouquet, many of which, with proper care in selecting the grapes and in fermentation, racking, and bottling, would rival in delicacy the productions of the Moselle. This care has not yet, however, except in some instances of limited production, been bestowed upon them.

Many European varieties have been grafted on American stocks in California and in other States, in the hope that their characteristics might be maintained, but it has been found, as previously stated, that they all tend to return to the type indigenous to the locality of the plantation, and it is probable that it is in some such type that the production of America will finally settle.

The quantity of the present wine production of the United States is about 30,000,000 gallons, which is divided as follows: California, 16,000,000; Ohio, 3,000,000; New York, 3,000,000; Missouri, 2,000,000;

Virginia, 1,000,000; New Jersey, 1,000,000; North Carolina, 1,000,000; the remaining 3,000,000 gallons being divided between Pennsylvania, Kentucky, Texas, Florida, Alabama, Georgia, etc.

Grapes are more used as a food in America than they are in Europe.

The custom into which Americans have fallen of calling their still wines by foreign names is most strenuously to be deprecated, and the action of the jury in diminishing the ratings of those exhibits to which foreign names are attached is to be commended. The detrimental result of such evil practices is plainly seen in the distrust that attaches to the shipments of Bordeaux, since it has grown so common a custom among her merchants to attach to blends of Spanish and Italian wines labels signifying that they are the pure production of the Medoc. This objection can not be made against the sparkling wines of America. They are all called by names distinctly indicating their origin, and generally made by strictly legitimate processes, *i. e.*, fermented in bottle. They are consumed with pleasure by those who like their taste, which is very much the same as that of a sparkling Moselle, although in some degree lacking the delicacy of the latter.

The cryptogamic diseases of the vine, mildew, black rot, oïdium, etc., give much trouble to growers. The difficulties of treating the diseases, and the numberless insect enemies of the producer, have been materially mitigated by the admirable work of Dr. Charles V. Riley, United States Entomologist, and other entomologists. The phylloxera, although a native of America, does not present among our resident stocks the same disheartening problem that it offers among the older and more delicate vines of Europe.

Wine production of the world, 1875 *to* 1891.

[Quantity in American gallons.]

Year.	France.*	Spain.	Jerez.†	Italy.	German Empire.	Austria.
1875	2,213,159,520	523,000,000	5,998,080	725,440,000	156.959,430	169,654,716
1876	1,105,019,520	537,504,000	4,184,664	760,320,000	153,120,000	63,075,777
1877	1,489,099,920	528,000.000	4,040,520	831,600,000	171,626,400	84,541,300
1878	1,286,234,400	518,548,800	3,364,680	670.612,800	80,877,173	177,695,311
1879	680,328,000	646,800,000	5,363,820	799,444,929	26,054,716	73,360,104
1880	895,382,400	618,288,000	6,589,440	914,385,095	13,832,497	45,434,400
1881	1,018,459,200	569,712,000	4,118,400	747,012,651	70,634,478	80,152,353
1882	1,026,590,400	540,672,000	3,091,968	1,110,109,704	42,189,009	88,898,360
1883	1,218,756,000	623,092,800	4,324,320	1,170.358,047	74,226,711	91,546,752
1884	918,211,166	580,800,000	4,501,200	521,238,514	78,571,096	88,901,100
1885	831,098,400	660,000,000	6,633,000	628,556,006	98,477,305	104,881,336
1886	661,663,200	567,600,000	6,576,900	971,562,622	39,711,281	97,115,040
1887	668,210,400	739,569,600	4,626,072	871,609,648	63,197,939	124,131,031
1888	794,696,786	608,591,000	6,909,408	797,744,640	75,561,374	109,685,664
1889	612,102,300	699,716,368	4,328,016	574,388,485	53,410,013	108,398,400
1890	783,790,033	888,949,670	4,290,000	777,659,757	78,588,983	95,383,200
1891	875,684,252	899,654,422	7,639,236	923,210,640	13,427,484	47,691,600

*Including Algeria. †Not including Sanlucar, Port St. Mary's, Moguer, etc.

Wine production of the world—Continued.

[Quantity in American gallons.]

Year.	Hungary.	Croatia-Slavonia.	Portugal.	Douro.	Madeira.	United States.
1875	165,270,811	41,317,703	130,750,000	7,700,000	921,464	12,954,961
1876	49,052,097	12,273,020	63,000,000	7,000,000	864,562	14,968,085
1877	94,298,682	23,574,670	132,000,000	10,360,000	852,751	16,942,592
1878	213,201,991	53,300,500	79,380,000	8,820,000	841,632	17,953,386
1879	166,698,655	41,674,660	68,640,000	7,560,000	833,412	19,845,113
1880	64,068.546	16,017,136	61,740,000	6,860,000	741,258	23,298,940
1881	111,691,272	27,922,318	70,560,000	7,840,000	694,371	18,931,819
1882	108,584,721	27,146,180	79,380,000	8.820,000	701,382	19,934,856
1883	122,393,964	30,598,490	60,480,000	6,720,000	685,721	17,406,028
1884	115,460,822	23,865,205	45,360,000	5,040,000	594,302	17,402,938
1885	143,158,620	31,598,424	66,780,000	7,420,000	587,624	17,404,698
1886	103,824,632	42,051,556	54,180,000	6,020,000	621,432	17,366,393
1887	130,973,119	33,627,348	63,000,000	7,000,000	654,721	27,706,771
1888	103,312,220	25,828,055	133,085 000	9,240,000	712,491	31,680,523
1889	119,387,400	29,846,850	65,520,000	7,280,000	764,772	26,617,034
1890	90,914,812	22,753,703	112,200,000	7,840,000	863,002	24,306,905
1891	50,624,000	15,645,201	115,300,000	7,560,000	887,634	23,724,890

Present average annual production.

Russia	75,000,000	Argentine Republic	39,600,000
Greece	39,600,000	Chili	39,520,000
Roumania	53,000,000	Cape of Good Hope	2,642,000
Switzerland	28,420,000	Australia	3,000,000
Turkey, including Cyprus	65,000,000	Tunis	2,500,000
Servia	72,800,090	Persia	739,00
Bulgaria	70,000,000	Canaries	3,950,000

IV.—SPIRITS.

KIND OF SPIRITS AND THEIR COMPOSITION.

The most important constituent in all alcoholic beverages is ethylic alcohol, or ethyl hydrate, the mono-atomic alcohol, C_2H_5HO. As is well known, this is produced by the action of the diastase of malt and yeast on a substance containing starch; the diastase converts the starch into dextrine and then into glucose, and fermentation being set up in the resulting fluid, the growth of the ferment splits up the glucose ($C_6H_{12}O_6$) into alcohol (C_2H_5HO) and carbon dioxide, CO_2. The yeast is not necessary for the purpose of setting up fermentation. That would occur spontaneously in such a saccharine fluid exposed to the action of the ferment germs existing everywhere in the atmosphere; but an unaided fermentation would be apt to be accompanied by the development of plants other than the pure alcoholic ferment, and the resultant alcoholic liquid would be sour, oily, bitter, or putrid. It is on this account that the yeast or pure alcoholic ferment is added, and every precaution taken to avoid the development of any other.

Ethylic alcohol was known to the Arabians, and its distillation was described by Geber, of Seville, in the eighth century; absolute alcohol is said to have been obtained about a century later by Rhazes, the head physician of the hospital of Bagdad; but the first well-authenticated anhydrous alcohol was isolated by the Russian, Tobias Laritz, in 1796. He used carbonate of lime. Richter obtained it in the same year by means of chloride of calcium.

After alcohol is generated in a liquid, its separation is the simple process of distillation in a retort. The only difference in different spirituous liquors is in the substances of which the mash, or liquid in which the alcohol is generated, is made. Bourbon whisky is made of corn, rye, and malt; rye whisky, of rye and malt; brandy, of wine; rum, of molasses; Scotch and Irish whisky, of barley, etc. The difference in quality in different kinds of whisky is infinitesimal, and for therapeutic purposes may be neglected, provided the taste of the patient is consulted. Some change takes place in spirits as they grow older, causing them to become smoother and less acrid to the taste. Spirits take from the wood of the ordinary cask only a light straw color. American whiskies are generally kept in charred barrels, and Dr. R. A. Witthaus has found that their color is due to a coloring matter generated in the burning between the charred surface of the stave and the unaffected wood of the interior. The coloring of French brandy is added caramel. The faint coloring of old Scotch whisky generally comes from the old sherry casks in which it is packed. If spirits be run through charcoal, the fusel oil, to which they owe their taste and smell, and all coloring matters are eliminated, and the result is a neutral spirit without odor, color, or taste. This substance may be made from inferior corn, bad molasses, beets, potatoes, or anything that happens to be cheapest, and when it is properly neutralized its source can not be detected; it is simply absolute alcohol and water, and is the "purest" substance known to chemistry. This is the "pure spirits" of the English, the "French spirits" of the American, the *trois-six* of the French, and is the substance in use all over the world to adulterate spirits of all kinds. It is hardly necessary to say that it is less injurious to the human economy than the substance it is used to adulterate, and that this explains why it is that the various commissions that have from time to time been sent forth to investigate the question of the purity of liquors have always found that the poorest were the purest, and the worst the best. *Trois-six* will always be used; it is the cheapest alcohol; its vice is that it has no taste and no smell. The other adulterations of spirits are of no importance. The only injurious component with which the man of science need concern himself is alcohol.

Whisky in America is said to be at proof when it contains about 50 per cent by volume of absolute alcohol, and 50 per cent of water.

It is generally supposed to be sold in this condition. It is generally so sold to the retailer because he has a hydrometer in his drawer and will weigh it when he gets it home; the consumer, not being so scientifically equipped, generally gets it between 80° and 90°, that is, with between 40 and 45 per cent of absolute alcohol. If spirits are kept in a warm, dry place, they will gain in alcohol; if in a cool, moist one they will lose. An instance is on record in which of two barrels of whisky, deposited at the same time in the same building at proof, one in the garret and the other in the cellar, one was found to be 10° above proof and the other 10° below when simultaneously removed. For this reason American whisky generally increases in alcoholic strength as it grows older, while French brandy decreases. Different kinds of spirits are generally sold at different degrees of strength: American whisky, gin, and New England rum at proof; new French brandy, Irish and Scotch whisky, and Jamaica and St. Croix rum at from 17 to 24 degrees above proof.

In addition to those already mentioned there are numberless other distillations of plums, apples, peaches, and various other fruits, some of which, particularly the peach and apple brandy, at a ripe old age, are not without merit. There are also arrack, made of rice, awa, of the Polynesian pepper, etc.; but the knowledge of these is of no practical use.

Looking upon spirits as beverages, we find as many opinions in regard to their flavor, hygienic qualities, etc., as there are consumers.

French brandy would probably receive, among civilized men, an immense majority of votes in its favor. When properly prepared, it would seem, as a beverage, to be preferable in many ways to any other spirit. It should be made of wine grown in one of four concentric elliptical districts lying about Cognac. The first in order of quality and the smallest in size is called the *Grande Champagne.* It runs off to the southeast from Cognac, and is bounded by a line running between that place and Châteaubernard, and through Charente, St. Merne, Viville, and La Chaise. It is about 17 miles in length and 10 wide in the largest part. The *Fine Champagne* lies around the first district, and is circumscribed by a line running through Cognac, Jarnac, Châteauneuf, Barbézieux, Jouzac, Pons, and Dompierre. It is irregularly circular in form, its longest diameter being about 28 miles and its shortest about 20. The third district, the *Fins Bois*, lies around the second, its boundary line running through Saintes, Matha, Rouillac, Blanzac, and St. Genis; it is about 44 miles in diameter. The *Bons Bois* is the outer district, its boundary line running through Royon, the charming little watering place on the Bay of Biscay, at the mouth of the Gironde, St. Jean d'Angély, Aigre, Angoulême, Montmoreau, and Montenère; it is about 55 miles in diameter. Outside of the *Bons Bois* there is no good Cognac brandy made.

The substance from which Cognac brandy, properly so called, is distilled is, as has been said, wine grown in or in the immediate vicinity of these four districts. It was formerly all distilled by the farmers and brought in barrels to the Cognac fairs, and sold on its merits to the merchants, who blended it according to their own taste and judgment. At present, many of the shippers purchase or make the wine and distill their own brandy. One or two of the leading houses fix the price for the vintage, and this price is usually maintained throughout the year. In years when there is not enough brandy of fine quality made to justify quoting it the vintage is omitted; and the quantity of this quality has been so small since 1877 that no quotation has been made since that year. This lack of wine is owing to the ravages of the phylloxera. Various means have been adopted by the growers to reconstitute their vineyards, the most efficacious of which is the planting of American stocks, and there is now a prospect that the crop may be sufficiently good to justify a quotation in 1888. The process of blending consists in mixing together brandies of different ages and localities to make a certain standard which is fixed upon for itself by each shipping house, and which it is endeavored to keep as nearly uniform as possible, so that the brandy of the house at one year of age shall always be practically the same. There are some three or four shipping houses in Cognac that still adhere to this virtuous and seemly way of making their brandy, preserving the traditions of the old days when, if a farmer was caught with any *trois-six* on his premises, his name and a statement of the facts were duly placarded on the door of the village church on the following Sunday. But after these three or four all the other shippers make up their various qualities and vintages by the addition of more or less *trois-six*, which detracts notably from the flavor and bouquet of the brandy to which it is added. If the *trois-six*, or pure spirits, is properly rectified, it does not, however, injure the brandy in any other way.

Brandy of inferior quality is made in nearly all parts of the world. It is very frequently distilled from a mash made with the pomace or refuse of the wine press, and is then exceedingly coarse and impregnated with acids and injurious oils. After Cognac, the brandy made in La Rochelle, known to commerce as Rochelle brandy, is the best. Spain is a large producer of brandy; it is generally consumed at home. The brandy made in California is generally coarse and of inferior quality; some attempts have been made to make a real brandy by distilling wine, and a good, clean spirit of little bouquet and flavor has been produced; but it has not been a pecuniary success, and the present efforts of the California distillers seem to be restricted to producing a spirit that can be used to advantage in blending with the production of Cognac and La Rochelle.

They have met with some success recently, and there is a small

European demand for their production. Notwithstanding the immense preponderance of inferior qualities called for by the trade the best brandies in existence are always to be found in this country by those who are willing to pay the price.

Next in importance to French brandy may be classed Scotch and Irish whiskies. These are both distilled from a mash made of barley, and are so much alike that some experience is necessary to enable the consumer to distinguish them with certainty.

American whiskies are divided into two great classes, Bourbon whisky and Rye whisky. Bourbon whisky takes its name from Bourbon County, Kentucky, whose production of this article first became celebrated. All Kentucky whisky made by the old-fashioned processes, known as sweet mash and sour mash, are now called Bourbon when they contain a certain quantity of corn. The proportion of the different constituents used in making the mash varies in each distillery, but it may be stated in a general way to be about eight-tenths corn, one-tenth rye, and one-tenth malt. In making sour-mash whisky no yeast is used. The meal is put into small tubs and scalded with slop, the refuse of a previous distillation; it is then left to cool, and afterward broken up into a homogeneous mass by a workman with a stick called a mash-stick; in modern establishments the "breaking-up" is done by a "rake" caused by steam power to revolve rapidly in the mash-tub. Water is added in the proportion of about 40 gallons to each bushel of grain, and the mash is then run into the fermenters, which are large vats varying in capacity from 200 to 4,000 bushels. The fermenting period varies from forty-eight to seventy-two hours, according to the kind of whisky to be produced. In the sweet mash process the meal is scalded with boiling water instead of slop, and the mash is made, cooled, and broken up in a large tub. The fermentation is then induced by the use of yeast, the production and use of which are the delicate touchstones of the distiller's art.

The fermentation having been carried to the point of the maximum production of alcohol, which by the most improved processes reaches five gallons for each bushel of grain, the wort, or beer, as the alcoholic liquor is then called, is pumped into the beer, or singling, still. Heat is then applied by a coil of steam pipes in the interior of the still, and the low wines, or singlings, pass over. The residue left in the beer still is the slop, or swill, used in the sour-mash process in scalding the meal. It is utilized ordinarily for feeding cattle and hogs, for which purpose it is most efficacious. The singlings generally contain about 70 per cent of proof spirit, or 35 per cent of absolute alcohol. After cooling, the singlings are run into another retort, or still, called the doubler, where they are redistilled, and the resulting whisky run into a tank, whence it is drawn into barrels, in which it is kept until it is ready for consumption.

Whisky made by the sweet-mash process arrives at perfection in four to five years; sour-mash whisky requires from three to four years longer to ripen, but it acquires more flavor and bouquet.

Pure rye whisky is made in the same way as Bourbon, except that no corn is used in making the mash. The slop from a rye-whisky distillery is generally thrown away, although it makes an inferior kind of food, and is sometimes used for cattle and pigs in connection with other substances.

The yield of a mash is increased by subjecting it to a high temperature, 212° F., for forty or fifty minutes before running it into the fermenters.

There is a difference in the character of the whiskies made in different parts of Kentucky. This difference is quite perceptible to the experienced taster, but the difference in the price of different brands is due less to the difference in quality than to the difference in demand caused by advertising and other arts of the merchant.

Some excellent rye whisky is made in Kentucky, but the general taste prefers this class of whisky made in Maryland and Pennsylvania. The Bourbons made in these States are considered inferior to the Kentucky article.

New England rum is made of a mash of molasses, and is manufactured almost exclusively in Massachusetts, but two distilleries existing outside of that State; one is located in Covington, Kentucky, and the other in New Haven, Connecticut.

Apple brandy is distilled principally in this country in New Jersey, Kentucky, Tennessee, and Connecticut, although there is some produced in New York.

Gin is made of a mash of rye; the juniper flavor is given to it by suspending a bag of juniper berries in the still during the last distillation. The largest producer of this spirit is Holland.

In addition to the ordinary spirits of commerce there is another class of beverages known variously as "liqueurs," "cordials," "bitters," etc. They vary in strength from Vermouth, with about 17 per cent of alcohol, to Absinthe and Bénédictine, with about 55 per cent, and sometimes more. They are all decoctions, made by mixing fragrant herbs in some way with spirits or wine. Each one has generally a salient perfume from which it derives its name, as Peppermint, Absinthe, Maraschino, Cacao, Anisette, Kümmel, etc. English gin is one of these. A description of the method of making vermouth may suffice for them all. Various quantities of absinthe, germander, hyssop, sage, centaury, saffron, enule, galangue, aromatic cane, gentian, benzoin, calisaya, quassia, cinnamon, zedorcia, cloves, coriander, aniseed, mushroom, and orange peel are put into a linen bag and hung in a white wine, which is kept at a temperature of about 150° F. for four or five days; the bag is then squeezed into the wine and replaced, and the steeping continued for

a month, the bag being squeezed at intervals of five or six days. The vermouth is then filtered and put into casks or bottles for shipment. The various "bitters" of trade are made much in the same way.

There is more or less fraud connected with almost all of these things, such as their being concocted by physicians, monks, etc. The most correct one is Chartreuse. That is made by the fathers at the Fourvoirie of the head house of the order, in Isère, France, near Voiron. The only desperate lying of which the good Carthusians can be accused is when they say they gather their own herbs, and use no spirit in their manufacture but *esprit de vin*. The fact is, they buy their herbs from the apothecaries, and the spirit is the old truepenny *trois-six* of Marseilles. But, as a distinguished physician is accustomed to say when anything goes wrong, "It's just as good, we might not have got anything," and we can forgive the gentle fathers for their pious deception, for the yellow Chartreuse is the best liqueur made in the world. The older it is the better it gets.

The Bénédictine made at Fécamp sets up a claim to a religious origin, but it is doubtful if its history could be traced back to an antiquity more remote than 1863. It is, however, of good quality, and some persons prefer its taste to that of Chartreuse.

THE COMMERCE IN SPIRITS.

The following tables give the production of spirits in France for a period of forty years.

Production and price of spirits in France since 1850.

Year.	Quantities produced.		Total production.	Average price per hecto. of absolute alcohol.	Quantities taxed.	Average per capita.	Production.	
	By professional distillers.	By agricultural distillers.					Wine.	Cider.
	In 1,000 *hectol.*	*In* 1,000 *hectol.*	*In* 1,000 *hectol.*	*Francs*	*Hectol.*	*Litres.*	*In* 1,000 *hectol.*	*In* 1,000 *hectol.*
1850	670	270	940	56	585,200	1,46	45,266	16,181
1851	816	220	1,036	53	622,805	1,74	39,429	2,512
1852	435	262	697	110	648,810	1,81	28,636	18,428
1853	616	110	726	128	644,352	1,80	22,662	8,444
1854	891	23	914	214	601,699	1,68	10,824	8,615
1855	690	12	702	145	714,813	2,00	15,175	2,946
1856	686	18	704	111	768,394	2,13	21,294	3,782
1857	859	24	853	109	825 089	2,29	35,410	3,017
1858	696	262	958	70	842,691	2,34	53,919	4,297
1859	772	260	1,032	69	823,629	2,28	29,891	11,613
1860	763	110	873	82	851,825	2,27	39,558	14,593
1861	769	262	1,031	100	832,926	2,23	29 738	8,859
1862	908	110	1,018	74	857,592	2,29	37,110	7,937
1863	1,007	220	1,227	67	879,264	2,33	51,372	9,910
1864	1,126	227	1,353	82	870,223	2,33	50,653	11,644
1865	1,777	364	1,541	62	873,007	2,34	68,943	2,784

Production and price of spirits in France since 1850—Continued.

Year.	Quantities produced.		Total production.	Average price per hec to. of absolute alcohol.	Quantities taxed.	Average per capita.	Production.	
	By professional distillers.	By agricultural distillers.					Wine.	Cider.
	In 1,090 *hectol.*	*In* 1,000 *hectol.*	*In* 1,000 *hectol.*	*Francs.*	*Hectol.*	*Litres.*	*In* 1,000 *hectol.*	*In* 1,000 *hectol.*
1866	1,255	136	1,391	44	964,223	2,53	63,838	14,675
1867	815	273	1,088	59	939,465	2,47	39,128	11,642
1868	1,031	261	1,292	64	971,317	2,55	52,098	11,696
1869	1,151	260	1,411	73	1,008,750	2,63	70,000	4,280
1870	902	335	1,237	57	882,790	2,32	54,535	19,194
1871	1,179	422	1,601	75	1,013,216	2,81	56,901	2,128
1872	1,439	452	1,891	54	755,464	2,09	50,155	4,597
1873	1,249	175	1,424	57	934,450	2,59	35,716	13,635
1874	1,348	184	1,532	75	970,590	2,69	63,146	13,312
1875	1,472	377	1,849	54	1,019,052	2,82	83,836	18 257
1876	1,408	301	1,709	43	1,000 182	2,71	41,847	7,036
1877	1,172	137	1,309	[illegible]	1,029,683	2,79	56,405	13,345
1878	1,260	157	1,417	58	1,100,512	2,98	48,720	11,936
1879	1,404	84	1,488	63	1,161,649	3,22	25,170	7,738
1880	1,556	25	1,581	68	1,313,829	3,64	26,677	5,465
1881	1,791	31	1,822	63	1,444,055	3,91	34,439	17,122
1882	1,733	34	1,767	56	1,420,344	3,85	30,886	8,921
1883	1,971	40	2,011	50	1,484,020	3,96	36,029	23,492
1884	1,873	62	1,935	44	1,488,685	3,98	34,781	11,907
1885	1,795	69	1,864	47	1,444,342	3,86	28,536	19,955
1886	1,822	81	1,903	44	1,419,888	3,80	25 063	8,301
1887	2,015	53	2,068	42	1,467,632	3,90	24,333	....
1888	2,011	58	2,069	43	1,468,443	3,80	30,102	....

Annual production of spirits by sources of supply since 1850.

Years.	Grain.	Molasses.	Beets.	Wine.	Cider.	Marc, lees, etc.	Fruit.	Various substances.	Total.
	Hectol.	*Hectol.*	*Hectol.*	*Hectol.*	*Hectol.*	*Hectol.*	*Hectol.*	*Hectol.*	*Hectol.*
1840–1850	36,000	40,000	500	....	815,000		....	....	891,100
1853–1857	69,000	137,000	300,000	....	165,000		....	....	671,000
1865–1869	84,018	346,640	300,449	....	553,983		....	60,124	1,344,614
1870–1875	108,483	582,443	313 771	....	539,762		....	46,611	1,591,070
1876	101,402	710,670	243,337	545,994	22,388	76,227	1,238	7,929	1,709,175
1877	163,204	642,709	272,883	157 570	9,468	56,191	1,062	5,796	1,308,881
1878	180,469	646,715	331,716	192,952	9,822	51,079	978	5,496	1,417,227
1879	247,171	723,631	364,714	102,651	7 265	36,831	438	5,178	1,487,879
1880	412,585	685,433	429,878	27,200	3,317	17,373	624	4,558	1,581,068
1881	506,273	685,646	563,240	34,324	2,291	24,621	603	4,289	1,822,287
1882	447,066	703,989	556 056	21,962	9,829	22,893	713	4,058	1,766,566
1883	561,932	750,637	629,998	22,710	8,088	28,918	1,408	7,325	2,011,016
1884	485,001	778,714	569,257	35,251	15,567	43,266	2,799	4,609	1,954,464
1885	567,768	728,523	465,451	23,240	20,908	43,853	7,680	7,028	1,864,514
1886	772,506	492,093	525,317	14,728	29,408	59,326	"	9,306	1,902,684
1887	738,753	426 462	793,006	30.892	17,178	39,639	"	22,645	2,068,575
1888	832,614	579,215	533,416	42,714	12,892	48,286	"	29,282	2,069,419
1889	....	....	720,638	....	....	....	....	....	....

From 1840 to 1875, the quantities given are the annual average.

The quantity of spirits distilled from apples, peaches, and grapes on which tax was paid in the United States during the fiscal years ending June 30, 1888, and 1889, was 888,107 and 1,294,858 gallons, respectively, and that from grain and molasses during the same periods, 70,677,379 and 75,868,671 gallons. In addition to the quantity on which tax is paid, there is probably a production of some millions of gallons of spirits in the country which escape payment of tax.

The internal revenue returns for the first 3 months of the current fiscal year (1891) indicate that the consumption of spirits in the country is increasing at the rate of between 8,000,000 and 10,000,000 gallons per anuum.

The following table shows the production of each kind of distilled spirits manufactured in the United States for each of the 12 years ending June 30, 1889:

Year ending June 30—	Grape brandy.	Bourbon whisky.	Rye whisky.	Alcohol.	Rum.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1878	178,544	6,405,520	2,834,119	10,277,725	1,603,376
1879	69,340	8,587,081	4,001,048	19,594,283	2,243,455
1880	129,086	15,414,148	6,341,991	21,631,009	2,439,301
1881	240,124	33,632,615	9,931,609	22,988,969	2,118,506
1882	381,825	29,575,667	9,224,777	15,201,671	1,704,084
1883	223,977	8,662,245	4,784,654	10,718,706	1,801,960
1884	200,732	8,896,832	5,089,958	12,385,229	1,711,158
1885	312,197	12,277,750	6,328,043	13,436,916	2,081,165
1886	329,679	19,318,819	7,842,540	11,247,877	1,799,952
1887	673,610	17,015,034	7,313,640	10,337,035	1,857,223
1888	864,704	7,463,609	5,879,690	11,075,639	1,891,246
1889	952,358	21,960,784	8,749,768	10,939,135	1,471,054

Year ending June 30—	Gin.	Highwines.	Pure, neutral or cologne spirits.	Miscellaneous.	Spirits warehoused. Total.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1878	364,963	19,412,985	11,108,023	4,096,342	56,281,597
1879	372,776	18,033,652	13,459,486	5,600 840	71,961,961
1880	394,668	15,210,389	20,657,975	8,265,789	90,484,356
1881	549,596	14,363,581	23,556,608	10,586,666	117,968,274
1882	569,134	10,962,379	27,871,293	10,744,156	106,234,986
1883	545,768	8,701,951	28,295,253	10,502,771	74,237,285
1884	641,724	6,745,688	28,538,680	11,426,470	75,636,471
1885	639,461	3,235,889	27,104,382	10,811,757	75,227,560
1886	659,607	2,396,248	26,538,581	10,543,756	80,674,059
1887	747,025	2,410,923	27,066,219	11,084,500	78,505,209
1888	872,990	1,016,436	29,475,913	12,603,883	71,144,110
1889	1,029,968	1,029,495	30,439,354	13,738,952	90,310,868

THE PROCESS OF DISTILLING SPIRITS.

The following extracts from the report of the Commissioner of Internal Revenue for 1889 give a good description of the process of distilling:

The object of the distiller is to separate the alcohol contained in the fermented wort from the foreign matter with which it is associated. For this purpose he has resort to a still. The alcohol thus produced is not, as has been well known for some time, a single substance, homogeneous, always the same in its nature, form, and effects; on the contrary, it is an extremely variable body, of diverse chemical composition and physical characteristics; it is not *one* alcohol but many, which chemists have divided into several series.

The distiller commonly divides the product of his still into three classes: (1) Products with a bad taste, the heads; (2) alcohol, properly speaking; and (3) products with a bad taste, the tails. The first and third are kept separate from the middle; which is the most valuable portion. The following table, according to Dr. Rabuteau, gives the boiling points of these different products:

	Boils at— Centigrade.	Boils at— Fahrenheit.
Products with a bad taste, the heads:		
Aldehyde	20.8	69.4
Acetic ether	72.7	162.9
Alcohol, grain, spirits, ethyl alcohol	78.0	172.4
Products with a bad taste, the tails:		
Propyl alcohol	97.0	206.6
Butyl alcohol	109.0	228.2
Amyl alcohol	132.0	269.6
Valerianic ether	133.0	271.4
Amyl acetate and other nameless products	136.0	206.8

It is fortunate that the products of the first class have such low boiling points that they can be got rid of very easily by fractional distillation, for they are dangerous poisons.

Aldehyde is a colorless, easily mobile liquid, having a specific gravity of 0.8009 at 0° C. (Kopp). Its vapor density was found by Liebig to be 1.532, who also states that when inhaled in large quantities the vapors, of a peculiar ethereal, suffocating odor, produce a cramp, which for a few seconds takes away the power of respiration. (Isidore Pierre compares its action to that of sulphurous acid.) It is miscible with water in all proportions, heat being evolved, and it is likewise soluble in both alcohol and ether. The addition of water raises the boiling point of aldehyde. It absorbs oxygen and is slowly converted into acetic acid. (Roscoe and Schorlemmer's Chemistry.)

Ethyl acetate or acetic ether is a mobile liquid possessing a penetrating, refreshing smell and a pleasant burning taste. It has a specific gravity of 0.91046 at 0° C. (Kopp). Its vapor density was found by Boullay and Dumas to be 3.016. It mixes with alcohol, ether, acetic acid, etc., in all proportions, and dissolves a large number of resins, oils, and other organic bodies. Its action in many cases, when used as medicine, resembles that of common ether, but it possesses a more agreeable taste and smell. It is also used for addition to the poorer classes of wines, liqueurs, etc. According to Prof. Dujardin-Beaumetz the toxic dose of aldehyde is from 1 to 1.25 grams, and that of acetic ether 4 grams per kilogram of the weight of the animal.

The tails or faints, as well as the still less volatile or ordinary fusel oil, are mixtures

of several alcohols and fatty acid ethers, their relative quantities depending on the nature of the materials used in mashing, belonging to the higher series of alcohols, and consequently possessing greater toxic effects.

Propyl alcohol was discovered by Chancel in 1853 in small quantities in fusel oil obtained in the manufacture of wine brandy. It resembles ethyl alcohol in its odor. It has a specific gravity of 0.8198 at 0° C., and boils, according to various observers, at from 96° to 98° C. The latter number is probably the correct one, as the boiling points of the normal alcohols increase 19.6° C. for every increment in composition of CH_2 (Grimshaw and Schorlemmer). It is miscible in all proportions with water, but, on the addition of easily-soluble salts, as calcium chloride, etc., it separates out from aqueous solutions. Propyl alcohol is not used in the arts or manufactures, but is chiefly employed in scientific research (Roscoe and Schorlemmer's Chemistry). It is, toxically, more active than ethyl alcohol; the dose is from 3 to 4 grams per kilogram of the weight of the animal.

Butyl alcohol occurs in varying quantities in several fusel oils, and is especially found in the spirits from beet root, potatoes, and grain. It was discovered by Wurtz in 1852. It is a somewhat mobile liquid, possessing a spirituous smell, but at the same time a fusel-oil odor resembling that of syringa flowers. It boils at 108° to 109° C., and has a specific gravity of 0.817 at 0° C. At ordinary temperatures it dissolves in ten parts of water, and the greater part is separated from solution on the addition of easily-soluble salts, chloride of calcium, common salt, etc. According to Rabuteau it is toxically four times as active as ethyl alcohol, its dose being 2 grams per kilogram of the weight of the animal. It has a toxic action on the heart and blood, producing muscular trembling and in large doses convulsive spasms.

Amyl alcohol, so called by Cahours because it was chiefly found in spirits obtained from bodies containing starch (amylum). It is commonly called potato spirits. It has been found since to occur in all fusel oils. Amyl alcohol was for a long time considered to be one distinct compound. Biot first drew attention to the fact that this body possesses the power of rotating the plane of polarized light to the left, and Pasteur, in 1855, pointed out that the rotary powers of different samples of amyl alcohol vary according to the source from which they are obtained. From this he concluded that the body termed amyl alcohol is a mixture in varying proportions of an optically active and an optically inactive compound. He succeeded in obtaining the two modifications of the alcohol, and experiments of later investigators have established that they do not possess an identical chemical constitution. Fermentation amyl alcohol is a colorless, highly refracting liquid, possessing a burning taste and a penetrating smell, boiling at 130°–132° C., and solidifying at — 21° C. Inhalation of its vapors produces difficulty of breathing, coughing, headache, and giddiness. It kills rapidly, according to Dujardin-Beaumetz, in doses of from 1.59 to 1.75 grams per kilogram of the weight of the animal. Even in small doses it exerts a powerful effect, bringing about intoxication and coma, producing at first a violent excitement of the nerve centers, followed by depression of the sensitive and motive forces.

Valerianic ether is a colorless liquid, having an irritating taste, and an odor which has been compared to that of apples; is met with in an extremely small proportion in fusel oils. The same is true in regard to amyl acetate, a colorless liquid of a peculiar and irritating taste, of an odor that recalls that of pears. Both of these substances have been little studied by chemists.

In short, very complex in their compositions, which are still very imperfectly known, the "spirits" of commerce contain not only the ethyl, propyl, butyl, and amyl series of alcohol compounds, on which most research has been concentrated, but also a certain number of other products, as pyridin and several aldehydes of unknown composition.

Drs. Laborde and Magnan have submitted a report to the French Academy of

Medicine, October 21, 1888, giving the results of their experiments with the higher alcohols and artificial bouquets, in regard to their toxic effects on animals, comparing the effects of the natural products with those of the artificial products. (Rev. Ques. 4 s., T. 2, 1888, pp. 1369, 1423.)

All spirits consist of a more or less diluted ethyl alcohol containing traces of the higher boiling compounds, commonly called fusel oil, the proportion depending on the care exercised by the distiller in stopping the distillation when the vapor temperature rises above the boiling point of ethyl alcohol, and certain flavoring bodies depending on the material employed. The deleterious effects of raw spirits are attributable to the presence of these higher-boiling alcohols, which by slow oxidation, by exposure to the air, are more or less changed and converted into certain ethers which are comparatively harmless.

Few accurate experiments have been made on the actual proportions of amyl alcohol present in whiskies. According to Dupré, a sample of Scotch whisky contains 0.19; of "Cape Smoke," 0.24, and of "Common Samshoe," of 0.18 of amyl alcohol per 100 parts of ethyl alcohol; that is, an average of one-fifth of one per cent.

A large proportion of the cheapest whiskies found in our markets is made by rectifiers by diluting "pure neutral" or "cologne" spirits to proof strength with water, adding some burnt sugar, caramel, or prune juice to color it, and certain artificial essences with a little tannin to give the desired flavors. Innumerable recipes are known to the trade for compounding from a barrel of cologne spirits, brandy, whiskey, either rye or bourbon, and gin as may be required. A slightly higher grade of cheap whisky is made by adding one part of highly flavored whisky to three parts of cologne spirits, diluted to proof strength.

V.—BEER.

Beer has been known to mankind since prehistoric times. It is spoken of by ancient historians as having been known to the Egyptians, who transmitted the art to the Greeks, and the manufacture has been continued without interruption to the present day. Beer is now made in nearly every country in the world. Bavaria, Germany, notably Bremen, Great Britain, Ireland, Austria, Belgium, and the United States, all make excellent beer.

The principal substances used in the manufacture of beer are barley, hops, and water, although other substances, such as rice, corn, oats, pease, etc., may be, and are, occasionally used to take the place in part of the more expensive barley. The following extract from a recent report of the chemist of the Internal Revenue Department contains the latest information concerning the statistics of Pasteur and others on the general subject of fermentation, and more particularly the manufacture of beer:

Under the general name of ferment or yeast, a large number of varieties and species are included, which resemble each other in form, but differ greatly in their properties and characters. The germs of these yeasts are everywhere floating in the air, especially in the hot summer months, and when they encounter a favorable soil for their development they grow and multiply like other plants under similar conditions; for instance, when they attach themselves to the stems and skins of fruit they give rise to the "spontaneous" fermentation of grapes, apples, pears, etc.

In addition to the yeast germs, the air of any locality contains numerous living organisms, the mold, bacteria, and other micro-fungi, for the most part injurious to the making of the wort and forming the true ferments of disease.

Among all these ferments several species will set up alcoholic fermentation in the wort and transform it into alcohol and carbonic acid, but all of them will not give a good product. On the contrary, the great majority of these spontaneous yeasts would have disastrous effects, for the brewer especially, decomposing the beer to such an extent as to render it unsalable.

The species called *Saccharomyces cerevisiæ* constitutes the large class of beer yeast proper, and the one the best known and studied. Two varieties of *Saccharomyces cerevisiæ* are extensively cultivated, the high or upper (Obergährung, fermentation haute) and the inferior or lower (Untergährung, fermentation basse). The former is used with a high 15° to 18° C. (59° to 65° F.) temperature, the yeast impurities rising to the top of the vat, whence they are removed by skimming; and the latter at a low temperature, between 4° and 10° C. (39° to 50° F.) where the fermentation takes place slowly and the yeast settles at the bottom in a compact mass. Each variety will produce its own peculiar and characteristic fermentation. A mixture of either of these varieties with one or several other species of *Saccharomyces* as *Sacch, ellipsoidens, mycoderma*, etc., results in disaster to the wort.

The wort naturally presents a proper soil for these harmful as well as for the proper or true ferments, and it is not surprising that the germs of the noxious flourish and develop, to the detriment of the true yeast plant.

These yeast plants and germs are so minute as to require the use of a microscope with high power objective to discern and differentiate them. Like all other fungi they are capable of distinct cultivation, and with the exercise of some care, and the assistance of a trained observer, a brewer or distiller, after some experiments, could maintain a crop of such particular yeast plants as yield the best results and give a uniform product.

This method of "pure" cultivation has been extensively employed in breweries in Denmark, Germany, and elsewhere in Europe, and there is no scientific reason why the same system should not be carried on in this country to the great improvement of our beers.

At the old Carlsberg brewery near Copenhagen, Prof. Hansen has cultivated two varieties of bottom *Sacch. cerev.*, which give different results in practice. One gives a beer well adapted for bottling, and is chiefly employed for home use. The other gives a good draught beer, containing more carbonic acid than the former variety; it is not adapted for bottling, but is much preferred by German brewers, and is therefore chiefly cultivated for export.

Experiments upon an industrial scale are being carried on at Burton-on-Trent, in England, with different species of pure yeast. Several varieties of *Sacch. cerev.* have been separated from the yeast generally employed and cultivated, which, when used on a practical scale, give entirely different results, both as to flavor, brightening, attenuation, and mode of separation of the yeast. Experiments have also shown that these characteristics can be maintained unimpaired throughout a very great many successive fermentations in the brewery. Cultivations have been started from a single yeast cell, and with proper care have been maintained for a long time.

On a commercial scale the cultivation should be conducted in sufficiently large vessels to yield the necessary amount of yeast used for fermentation. For this purpose two vessels should be employed, one in which the wort used for cultivation is sterilized by being boiled, then stirred and aërated, excess of pressure being prevented by means of air filtered through sterilized cotton; into the other (the fermenting vessel, previously sterilized by steam) the sterilized wort is forced, and pure yeast from the laboratory added. When the fermentation is at an end the liquid is run off, the apparatus filled with wort, stirred, and very nearly emptied. The wort so obtained and containing yeast, is then transferred to the brewing vessels; the residue in the apparatus, with the addition of sterilized wort, serves for the future production of

yeast. Pure yeast can thus be continually obtained without fresh inoculation, as the small amount remaining in the fermenting vessel serves this purpose. These vessels are jacketed and provided with the necessary safety valves, ventilators for admitting filtered air, exit tubes for the escape of steam and carbonic acid, thermometers and manometers for regulating temperature and pressure, and inlets and outlets for wort, beer, and yeast.

The following table gives a determination of the percentage of absolute alcohol in some of the best known beers:

	Per cent.
Strasbourg, G. Frick	4.79
Mülhausen, J. Dauner	4.27
Lillie	4.2
Culmbach	4.28
Munich	3.80
Augsburg	4.11
Munich:	
Salvator	4.35
Royal Brewery	4.41
Spaten	5.23
Zachert	4.5
Loewen	4.49
Kitzingen	4.72
Stuttgart	4.0
Wurzburg	4.2
Kitzingen, Ehemann	4.88
Nuremberg	4.60
Frankfurt, Henninger	4.57
Bamberg	2.83
Libotschan	3.27
Dresden, Waldschlosschen	3.31
Dresden:	
Feldschlosschen	2.94
Royal Brewery	4.49
Plauen	4.34
Cobourg	3.9
Berlin (weiss)	2.60
Jena	3.01
Hamburg	3.98
Berlin, Kiler	6.6
Saarbruck	4.81
Pilsen	3.39
Prague, Prelats	4.32
Budweis	3.55
Vienna	4.05
Vienna, Dreher	4.1
Brussels	5.80
Milwaukee	4.8
Philadelphia	4.9
St. Louis	5.1
Cincinnati	5.1
New York	4.6
PORTERS.	
London, Barclay, Perkins & Co	5.5
Dublin	4.7
Brown Stout	5.0
Extra Stout	9.0
Double Brown Stout	6.33
ALES.	
Burton	6.2
Scotch	5.8
India Pale	5.41
Export	7.3
Edinburgh	8.5
Common London	5.0

The production of the ten largest lager-beer breweries in the world in 1888 was—

Brewery.	Where located.	Barrels.
Anheuser-Busch	St. Louis	465,943
Spaten	Munich	413,850
Dreher	Vienna	390,029
Empire	Milwaukee	347,410
Schlitz	do	319,837
Ehret	New York	311,337
St. Marc	Vienna	290,480
Lowenbrau	Munich	337,739
Bergner & Engel	Philadelphia	241,143
Pschorr	Munich	228,366
Liesing	Vienna	251,739

The Anheuser-Busch Brewing Company of St. Louis, Missouri, is the largest brewery in the world. Its production in 1888 was 510,313 barrels, in 1889, 600,000, and in 1890, 700,000. It enlarged its capacity in 1891 and is now (1892) producing 6,000 barrels a day. The business employs some 2,500 men, consumes about 3,000,000 bushels of barley, nearly 2,250,000 pounds of hops, and 600,000,000 gallons of water. The Association bottled in 1888, 27,000,000 bottles of beer. A large bottle factory at Belleville, Illinois, is kept at work all the time making bottles for this concern. Its establishment at St. Louis covers over 400 acres. The piping of the brewery is more than 100 miles in length. The present annual capacity of the house is more than 800,000 barrels.

The method of Pasteur for sterilizing germs is adopted by the Association for their export beer, and the product of the brewery has now gained a certain footing, not only on German ships sailing from New York, but in Germany itself. The total annual exports exceed 5,000,000 bottles.

As our country is entitled to the credit of having the largest brewery in the world, it is only fair to add that she owes it almost entirely to the energy and ability of the President of the Anheuser-Busch Association, Adolphus Busch.

The French are working hard at brewing and have made beer a fashionable drink, but up to the present time their production leaves much to be desired in the way of quality. It is probable, however, that it is only a question of a few years when they will make as good beer as anybody in the world.

VI.—CIDER.

Outside of the French exhibits there were but two exhibits of cider, one from the United States and one from Great Britain.

There is annually produced in France from 14,000,000 to 15,000,000 hectolitres of cider. The greater part of this is consumed near the places of manufacture, but there is an increasing proportion now consumed in Paris and other cities. A portion of the apples worked by the factories are imported from Switzerland, Austria-Hungary, and Germany.

The cider of Normandy is becoming well known in the large cities and well deserves its good reputation. In the manufacture of cider we have, first, the extraction of the juice from the apples, second, the fermentation, and then the preservation of the cider which requires much care.

The season for gathering the fruit lasts from October to January, and the fabrication of the cider is carried on during the winter. Care is taken to prevent injury to the fruit prior to its manufacture, otherwise, mold and ferment would set in and could not easily be removed when the apples were crushed.

In making the cider, the apples are chopped or rasped into pulp and allowed to macerate in vats for about twelve hours, and the pulp is then put in the press. With the powerful compound presses now employed it is possible to extract from 70 to 75 per cent of the weight of the fruit in pure juice. Water is then mixed with the residue in the press, and it is further submitted to pressure to extract the soluble principles remaining therein.

The juice is fermented in large casks. This first fermentation is necessary to obtain the limpid cider. Then comes the drawing off or racking, which separates the cider from the lees or dregs. After this operation the liquid still contains a certain quantity of sugar necessary to the continuation of the fermentation.

Most of the cider-making has heretofore been carried on on the farms, but in recent years many factories have been established. The process of manufacture does not differ essentially from that practiced on the farms, but the special buildings for storing the fruit and the superior machinery result in a better quality of cider. Steam takes the place of hand power in working the chopping machines, and the ordinary hand presses are replaced by the hydraulic press.

Within the last 10 years the process of diffusion has begun to take the place of presses in the extraction of the juice. Water is used in the diffusers. The result obtained is to extract all the juice possible, and to obtain a must or wort identical to the pure must given by the press, possessing the same rich principles. The first cider factory operating by diffusion in France was erected at Ham. The process employed is as follows:

The apples are cut by a special apparatus into slices which are put into the diffusing apparatus. The diffusers consist of a series of vats which are movable and easily reversed, and connected by a complete system of piping which permits the distribution, at will, of water and juice.

The proper fermentation of cider is often difficult. After complete fermentation few ciders contain more than 6 to 8 per cent alcohol, though sometimes there may be from 9 to 11 per cent. As long as the alcoholic fermentation continues and produces on the surface of the mass an atmosphere of carbonic acid, the cider will be in good condition, but when it is no longer thus protected from the air, an acetic fermentation begins and the cider becomes vinegar, as is often the case with the light white wines.

One method of preserving is in large reservoirs, securely closed to prevent contact with the outer air, and at the same time they are kept at a low temperature in order to prolong, as much as possible, the alcoholic fermentation. When the cider no longer generates carbonic acid gas, an artificial atmosphere of this gas should be introduced into the reservoirs.

Preservation may also be secured by a low temperature, which has been found not to destroy the ferment, though kept at the freezing point.

Part of the water in the cider is congealed, and the other soluble substances and the flavor is concentrated in the portion remaining liquid. When raised to an ordinary temperature the fermentation again sets in of itself. By a high temperature, from 108° to 120°, all fermentation is destroyed in the cider and it acquires a cooked taste, but by the addition of new ferment this flavor disappears.

The production of cider in France, in 1886, was 8,300,758 hectoliters, and in 1887, 13,436,667.

The average production during the past ten years was 14,746,704 hectoliters. The principal production is in Normandy, Brittany, and the Departments that make little or no wine.

TROCADÉRO PALACE AND GARDEN, S

HOWING HORTICULTURAL TENTS.

NINTH GROUP.

HORTICULTURE.

By DAVID KING,

U. S. Expert Commissioner for the Ninth Group.

(EXTRACT FROM THE OFFICIAL CLASSIFICATION).

NINTH GROUP.

HORTICULTURE.

CLASS 78.—*Conservatories and horticultural apparatus.*

Gardeners', nurserymen's, and horticulturists' tools.
Apparatus for watering and keeping turf.
Large conservatories and their appurtenances. Room and window conservatories.
Aquariums for aquatic plants.
Fountains and apparatus for the ornamentation of gardens.

CLASS 79.—*Flowers and ornamental plants.*

Species of plants and specimens of cultivation, exhibiting the characteristic types of the gardens of the natives of every country.

CLASS 80.—*Vegetables.*

Species of plants and specimens of cultivation, indicating the characteristic types of the kitchen gardens of every country.

CLASS 81.—*Fruits and fruit trees.*

Specimens of plants and specimens of the products of cultivation exhibiting the characteristic types of the orchards of each country.

CLASS 82.—*Seeds and saplings of forest species.*

Species of plants and specimens of the products of cultivation exhibiting the methods of forest planting in use in each country.

CLASS 83.—*Hothouse plants.*

Specimens of the methods of cultivation in use in various countries for pleasure or utility.

HORTICULTURE.

By DAVID KING, Expert Commissioner

The French Universal Exhibition of 1889 occupied very nearly the same area and situation as that of 1878. The Trocadero Garden and Palace, which were comprised in the Exhibition grounds, were set apart for horticulture, and the products of floriculture, arboriculture, sylviaculture or market culture, were here admitted to compete for prizes.

No efforts were spared to make the horticultural exhibition as complete and interesting as possible. Owing to a different system of arrangement of buildings as compared with that adopted in 1878, a much more comprehensive, simple, and effective method for the display, was obtained.

Although no material alteration was made in the disposition of the alleys and masses of verdure, as originally laid out when the permanent garden was designed, yet by an intelligent distribution of the various subjects, study and comparison were rendered easy, without marring the general effect.

From the time when the Exhibition was determined upon, a commencement was made in preparing the gardens. The plans were settled in August, 1887, and measures were at once taken for leveling the grounds, laying out the walks, the alleys, and the shrubberies.

In October and November of that year, quantities of soil were brought in, and some 400 large trees, many of the variety *Platanus*, were transplanted; the latter were some 40 feet in height, and 36 inches in circumference 5 feet from the ground.

The work was carried on under the direction of Mr. Laforcade, and the constant supervision of Mr. Alphand, to the intelligence and experience of both of whom, is largely due the great success of the Exhibition in this department. Mr. Laforcade is the head gardener of the city of Paris, has been in municipal employ for over 33 years, and his services have been rewarded by a decoration of the Cross of the Legion of Honor. Mr. Alphand, for many years undisturbed by changes of government, has had the supreme direction of the public works department of Paris, and the mar-

vellous creations of the Bois de Boulogne, the Parc Monceau, the Buttes Chaumont, etc., are due to his remarkable genius for horticultural design.

Mr. Alphand has been decorated with the Grand Cross of the Legion of Honor, and as a further mark of appreciation, the municipal council propose to give his name to one of the new boulevards.

The municipality of Paris, possessing at the Bois de Boulogne many unique specimens of trees, allowed them to be transplanted on the Champ de Mars and Trocadero Garden; among them were maples, birch, catalpas, laburnum, walnuts, mulberry, poplar, plane, elms, and silver limes, and which were much admired both by connoisseurs and the general public.

In addition to the ornamental trees, there could be counted in the gardens upwards of 600 varieties of shrubs of different families. Seldom has so extensive a collection of such fine specimens been met with in public grounds.

As to the grass plots, it was no easy matter to have green lawns ready at the opening in May, by sowing of grass seed. Mr. Laforcade, therefore, framed and prepared a vast lawn at the Bois de Boulogne, capable of furnishing for use more than 30,000 square yards of green turf.

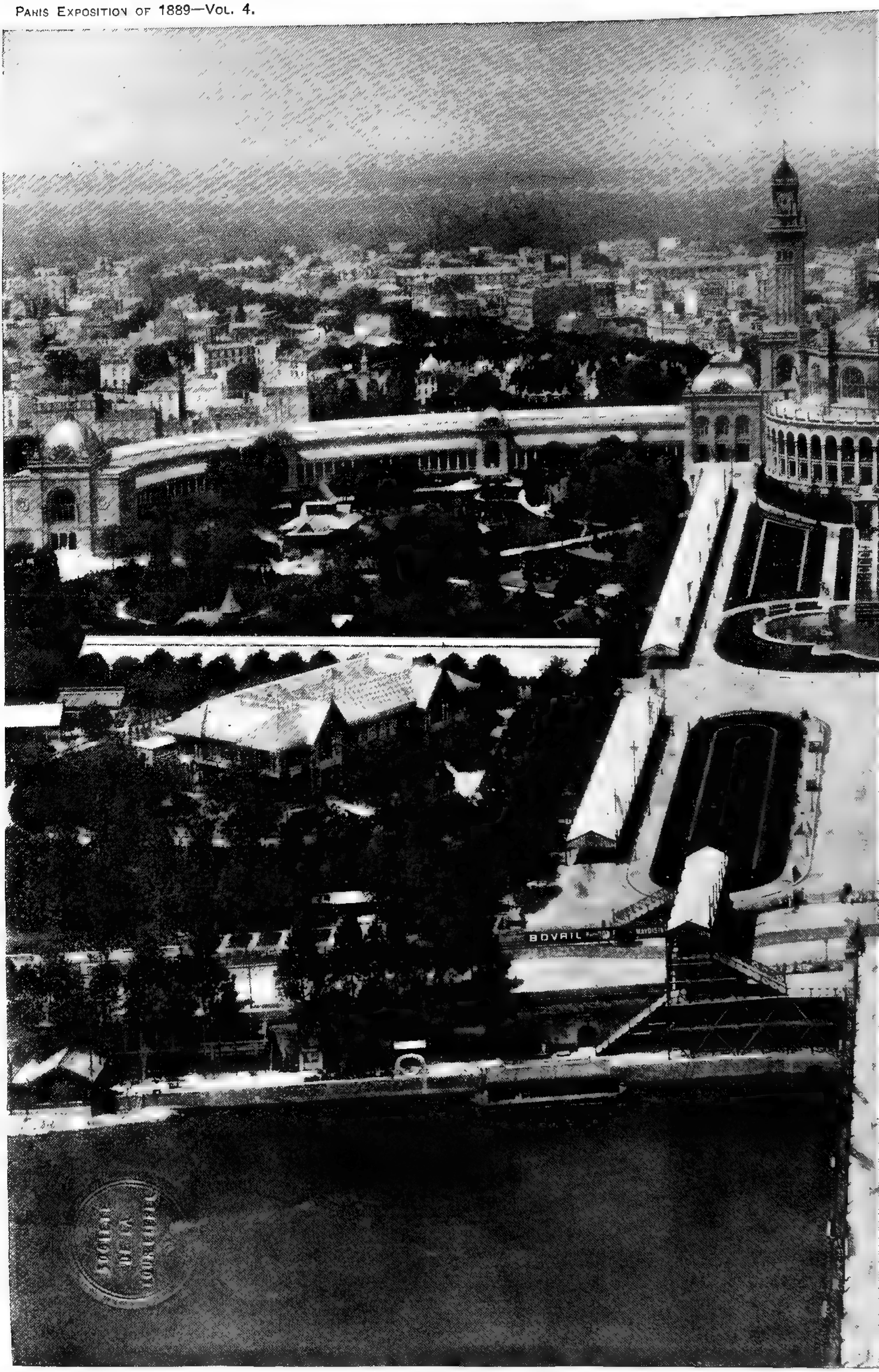
By April 10 the grounds of the Trocadero were in very good order; some 10,000 standard rose trees had been planted, with an under grouping of as many or more rose bushes; the standards were firmly supported by a line of heavy galvanized iron wire, stretched upon low, half-inch iron posts.

The grounds of the Champs de Mars were then, to the eye of the general observer, in a chaotic state, the roads deep with mud, and the debris of new construction lying about, while here and there were beds and plantations of rhododendrons or ornamental shrubs.

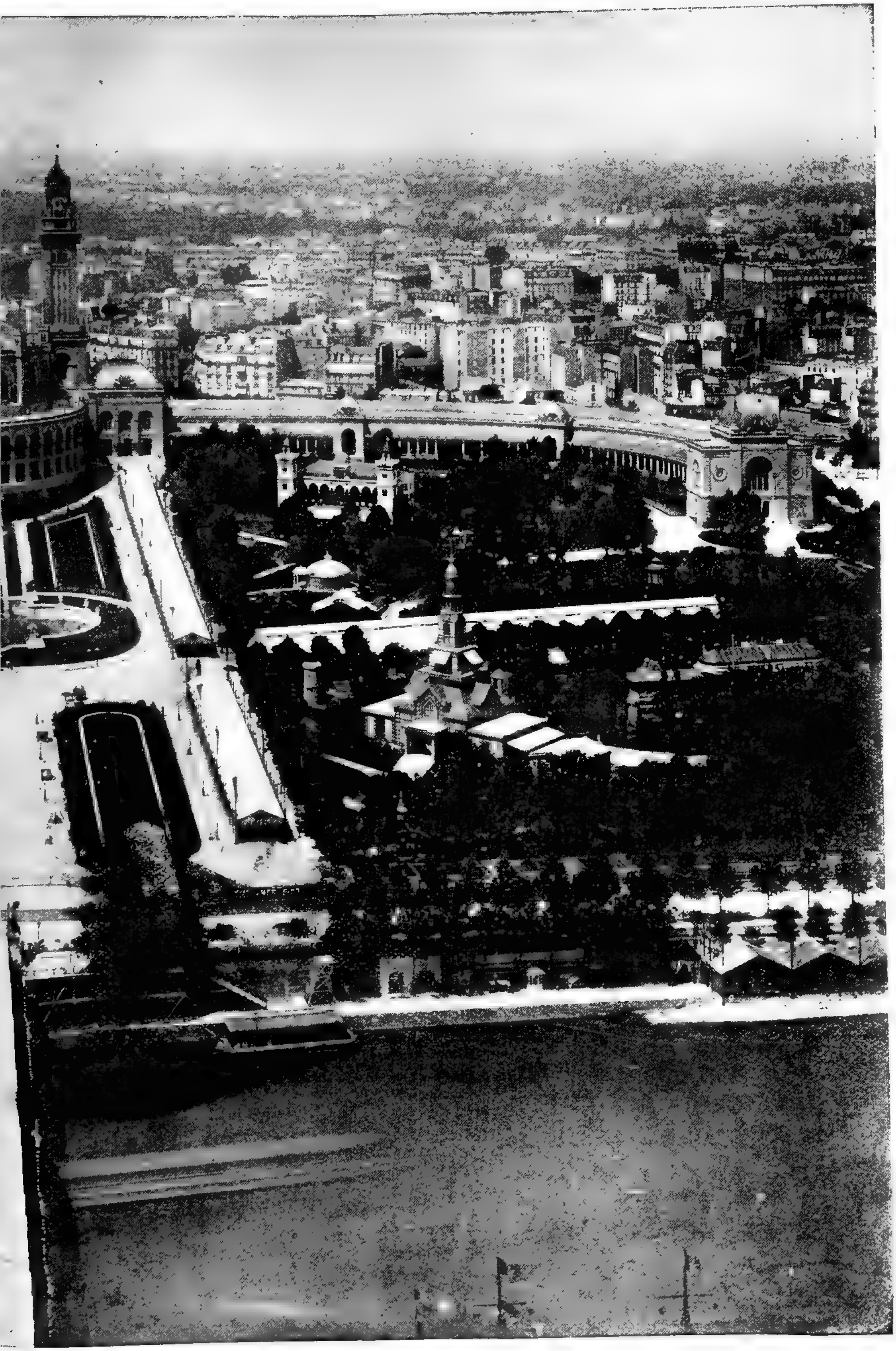
By April 23 a general clearing up had been commenced, more shrubs planted, the roads filled in, and pathways taking their proper course.

On May 6 when the Exhibition was opened, all the grounds were transformed into a garden in perfect order; the laying out was so skilfully managed, that the trees and shrubs in no way interfered with the beautiful vista, extending from the Palace of the Trocadero southerly across the Pont d' Jèna and the Champs de Mars, to the so-called Central Dome (a distance of some 1,250 yards), the magnificent arches of the Tour Eiffel spanning the center, and producing a grand effect.

The gardens may be considered as forming three separate and independent features of decoration, viz: The Trocadero, Champs de Mars, and the Esplanade of the Invalides; the plans [Pls. XXIII and XXV, Vol. I] and the general view at the end of this volume [Pl. I.] show the disposition of these grounds.



TROCA



GARDEN.

The Trocadero Garden [Pls. II and III] occupied the entire space between the quay on the Seine and the Trocadero buildings. The area was divided into four compartments, in each of which were beds devoted to shrubs, flowers, conifers, rhododendrons, magnolias, fruit trees, etc., the number of such beds being 107, and the estimated number of plants 100,000; this display was made by about 100 exhibitors.

The extreme outer limits of the grounds were set apart for hardy fruit trees, of both the ordinary and espaliated forms and varieties, the planting of which was completed in most cases in the autumn or spring previous to the opening of the Exhibition. These trees, notwithstanding their mature age, were in most cases flourishing and growing well, and in season many of them bore specimens of fruit. This excellent condition of these somewhat forced plantations, was equally apparent in the case of the merely ornamental trees, profusely scattered over the grounds.

The buildings in this garden comprised, fourteen pavilions or kiosques, besides two very large and long tents, double roofed, well

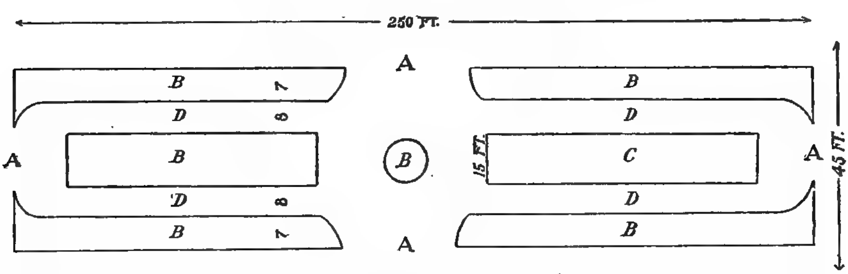


FIG. 1.—A.—Doors of canvass to loop up. B.—Beds for plants 7 feet wide. C.—Large table 2 feet high by 15 feet wide for grouping plants. D.—Pathways 8 feet wide.

ventilated at the peak, made with striped canvas, and the sides and ends of same material.

As the competition for prizes in the different horticultural epochs took place in these tents, a cut showing the plan is annexed. Fig. 1.

When in September and October the fruit exhibitions took place, pine tables were placed on the beds, B, in one of these tents.

Another building was devoted exclusively to the forestry of France, a view of which is annexed to a description of this very interesting forestry exhibition.

There was also a Japanese garden, in which were importations from that country, and a small house of bamboo and wood in keeping with its surroundings.

The garden in the Champs de Mars measured about 10 acres; it was laterally bounded by terraces with balustrades, which were reached by wide flights of steps here and there. Just under the terraces were borders of rhododendrons, which when in full bloom were the ad-

miration of all visitors; at different distances were magnolias about 15 feet high. On the terraces were planted 60 palm trees, some 15 feet high, exhibited by Besson Frères, of Nice, and seldom has there been seen outside of the tropics, so fine a collection of *Chamærops excelsa.*

The center of this garden was occupied by a vast grass plot, with borders and groups of shrubs and flowers; these were from time to time renewed, according to the season, until the close of the Exhibition.

The panorama (Plate XXVI, Volume I) taken from the Tour Eiffel, gives a general view of this, as well as of another garden above, extending to the central dome and measuring some six acres. In the center was a carpet of flowers surrounded by shrubs and climbing plants; rows of plane trees some 40 feet in height, transplanted more than a year ago, bordered the buildings which were on both sides. These gardens formed one of the great successes of the Exhibition.

The separate pavilions and buildings constructed by foreign commissions, scattered over the grounds of the Champ de Mars, were for the most part surrounded with living specimens of their indigenous arboriculture and floriculture. (Plate IV.)

Around the Mexican building (Plate V) was shown on two sides, a very large and fine collection of the Cactus family, all labeled, and among them some 18 plants of the *Agave americana,* with the flowering stalk removed, showing the hollow cup from which the sap had been drawn to produce *pulque,* the national drink of the Mexicans. Other varieties of the family, yielding hemp and Mexican grass of commerce, were also planted.

The small grounds around the pavilions of Venezuela, Bolivia, and San Salvador also abounded in displays of their native vegetation; the latter had especially an horticultural annex, in which, besides fine coffee plants, there were specimens of ferns, palms, and plants of *Attalea maripas, Cibotium Schiedei;* also specimens of the woods of the country, medicinal plants, models of fruits, etc.

But Brazil did more to illustrate its native flora than any of the other countries, commissioning for this purpose Mr. Lucien Linden, of the Leopold Park, Brussels, the director of the International Horticultural Company, and this was well done, although on a limited scale, in gardens, grottos, and greenhouses. The open-air garden contained acacias, cannas, musas, and some of the coniferæ, and in a pond artificially heated, were living plants of the Victoria Regia, in excellent condition. In a very pretty, small greenhouse was a choice collection, such as *Croxylon niveum, Artocarpus Vanoni, Anthurium, Schertzerianum crystallenum, Cocolobium pubescens, Talandsia hieroglyphica,* and *Viresia hieroglyphica, Microlessia hirta crestata, Dracœna Lindeni, Philodendron Melinoni, Dœffenbachia Bansei, Artanthe magnifica, Philotenium Lindeni,* and many more rare foliage plants.

A BUILDING SURROUNDED

WITH PLANTATIONS.

MEXICAN BU

LDING

The grounds of the Esplanade des Invalides formed a large and attractive portion of the Exhibition, and included various buildings containing products of the French colonies and protectorates, the surroundings being made pleasant by plantations of shrubs and flowers, indigenous to the respective countries.

From the Botanical Gardens of Algeria were brought good specimens of sugar cane, dwarf palm, sabal havanense, plantains, and different bamboos. In the Netherlands-India inclosure were vigorous tobacco plants, musar, capsicums, and cacti. In the various stalls and kiosques, the fruit products of Algeria, Morocco, Tunis, Egypt, and Madagascar were offered for sale by natives of the respective countries. In the Javanese huts were preserved specimens of the fruits of Java.

The contributions from the United States in this department were without great importance. This was to be regretted, as, although from a commercial point of view no great advantage was to be anticipated, yet in many cases a comparison of the developments of many indigenous American plants long since introduced and cultivated in Europe, and frequently modified by artificial transformations, natural influences, change of climate, and soil, would have been extremely interesting. There are a number of plants and shrubs quite familiar in North America, comparatively unknown in France except to the scientific botanist, a carefully selected collection of which, could not have failed to excite interest. The cultivated blackberry is absolutely unknown, and only very recently attention was called here, in a horticultural review, to the advantages to be derived, in utilizing unproductive marshy lands, by cultivating cranberries.

The exhibitions from the United States were, by catalogue, as follows:

NINTH GROUP—HORTICULTURE.

Class 78.—*Conservatories and horticultural apparatus.*

Division of Entomology, Department of Agriculture, Washington, District of Columbia, collective exhibit of pumps, blowers, etc. Contributors: Messrs. Deakin & Co., Philadelphia, Pennsylvania; W. and B. Douglas, Middletown, Connecticut; J. G. Evenden, Chicago, Illnois; Frank H. Heissinger, 196 Broadway, New York; W. J. Johnson, Newton, Massachusetts; P. C. Lewis, Catskill, New York; National Manufacturing Company, Boston, Massachusetts; New England Butt Company, Providence, Rhode Island; A. H. Nixon, Dayton, Ohio; A. B. Prouty, Worcester, Massachusetts; Rumsey & Co., Seneca Falls, New York; W. T. Vose, Newtonville, Massachusetts.

Frank H. Heissinger, 196 Broadway, New York; designs for landscape gardening, conservatories, etc.

Class 81.—*Fruits and fruit trees.*

Division of Pomology, United States Department of Agriculture, Washington, District of Columbia; photographs of orchard and fruit farm scenes.

CLASS 82.—*Seeds and saplings of forest species.*

Charles S. Sargent, director of the Arnold Arboretum, Jamaica Plains, Massachusetts.

A bronze medal was awarded to B. E. Fernow, Washington, District of Columbia, for brochure on American forestry in group IX, class 82.

The programme for the exhibits of horticulture, was arranged in a pamphlet of some 92 pages, issued from the Department of Commerce and Industry, circulated in France, and sent to the countries which were likely to take part in the Exposition.

The pamphlet contained:

First.—The general regulations under which all persons interested in the cultivation of plants from any country were invited to take part and compete. The exhibitions were divided into eleven epochs, or international horticultural competitions, extending from May 6 to October 23, and covering 6 days each; the time intervening was employed in removing the old plants and substituting the new.

Second.—Special regulations governing the exhibits, which were classified under the six heads, as given at the beginning of this report, and therefore unnecessary to detail here.

Third.—Detailing very minutely what was to constitute the particular competition in each epoch, as for example:

SECOND EPOCH—MAY 24 TO 29.

CLASS 79.—*Flowers and ornamental plants.*

1st. Ornamental plants.
2d. New vegetable plants discovered since 1878.
3d. Finest specimens of same.
4th. Cut flowers, the best general collection, and the best collection of varieties in each kind.
5th. Ornaments in natural flowers, bouquets, baskets or fancy arrangements.
6th. Baskets of plants in flower or in leaf.

CLASS 80.—*Vegetable plants.*

1st. All vegetable plants.
2d. New plants, whether imported or grown from seed, and hitherto undescribed.
3d. New plants since 1878.
4th. Finest specimens of vegetable plants.

CLASS 81.—*Fruits and fruit trees.*

1st. Trees, standard and grafted varieties, fruits for the table or domestic or industrial economy (except cider fruits).
2d. Fruit trees for cider.
3d. Fruit trees and shrubs from the South.
4th. Dwarf trees and shrubs.
5th. Forced cultivation of trees, shrubs, or vines in pots.
6th. Fruits, fresh preserved from the South, forced fruits, forced grapes.
7th. New fruits since 1878 grown from seed or undescribed trees.

CLASS 82.—*Seeds and saplings of forest kinds.*

1st. Deciduous trees used in replanting forests.
2d. Resinous trees for same purpose.
3d. Shrubs, bushes, etc.
4th. New varieties of trees.
5th. Finest specimens of forest trees.

CLASS 83.—*Plants grown under glass, such as hothouse plants, cold-house plants.*

1st. Orchids, Ixoras Calceolarias, Cinerarias, Amaryllis, Azaleas of India, Rhododendrons of Java and Himalaya, plants of New Holland, Araucarias, Coniferes, Anthuriums in flower, Ixias and Sparaxis in flower, Bonaparteas and Dasylirions, Primulas sinuensis, etc.
2d. New plants, one or several introduced most recently into Europe; one or several introduced into France direct. Lot of hybrid plants whose parentage is declared. One or more flowering or leafy plants obtained from seed and not yet in commerce. The same, but new since 1878, and in commerce.
3d. Four minor competitions relating to excellence of cultivation and maximum of development.
4th. Special cultivation of flowering or leafy plants for supplying markets.

The first half of the first day in each epoch, was reserved for the exhibitors and the jury, the public being only admitted after midday.

All plants were distinctly marked and described, with both the common and botanical names. The principal exhibitors were professional horticulturists, and the competitions brought out the best specimens of their art.

May 6 was the date of the official opening of the Exposition as well as of the first competition in horticulture.

For this epoch, a catalogue of three and a half pages printed the names and addresses of the exhibitors, the class, and the exhibit; for example:

Asset (Eugène), Sèvres, Seine-et-Oise, one lot of pansies.

The more noticeable of the exhibits were as follows:

Tulips, in great variety and beauty, the finest being sent from Holland; some of these were planted in beds outside of the tents, the stems being supported by a simple galvanized iron rod with a small hoop just under the flower; the exhibitor offered for sale, by special catalogue, some 250 varieties. Some of the more noticeable (of single and early) were:

Belle Lisette, rose and white.
Belle Rose, rose and white.
Bruid Van Haarlem, pure white.
Cerise d'Espagne, striped cherry and white.
Cerise Grisdelin, poppy colored, extra.
Claremond, white.
Cottage Maid, rose and white.
Dorothée Blanche, white and crimson.
Donna Maria, cherry.

Duc de Thole, in nine different colors.
Duc de Chatres, orange.
Grand Duc, yellow and red.
Grootmeester, striped cherry, also pure white.
Little Dorritt, orange mixed.
La Vièrge, rose white, carmine border.
Pottebaker, in four colors.
Roi Pepin, mixed cherry.
Standard d'Or, yellow and crimson.
Superintendent, violet striped white.
Victoria, carmine and white.
Prince de Lygne, a gorgeous yellow.

Narcissus in great variety, with names such as *Leedsi superbes*, *Bicolor grande*, Sir Watkin, *Nelsoni Aurantius* (hybrid), *Triandus albus*.

The system pursued in Holland in the cultivation of tulips and narcissus, as also hyacinths and crocuses, is as follows:

FORCED CULTIVATION IN POTS.

Tulips are planted in pots of a size graded according to the number of bulbs to be propogated. If single plants are desired the pot should be 5 inches deep by 5 inches wide.

The planting should commence September 15, when the pots should be filled with a good, light vegetable earth of mold, or of light heath soil, and the bulb sufficiently covered that the neck should remain even with surface of the soil. The pots are then buried outside in the ground, and up to the brims, leaving them for six or eight weeks, taking care to cover them with a light bed of leaves if there is danger of frost.

After this the bulbs will throw out roots and the leaves appearing, the tulips are then in a condition to be forced.

Then remove the pots to an apartment, hotbed, or greenhouse, placing them in the light and giving them as much air as possible. They must be heated gradually, great care being taken to water them, and never allowing the earth to become dry.

OPEN AIR CULTIVATION.

Plant the bulbs from September 15 to November 15 in a light, sandy soil, well worked over, in which the manure is not too fresh, using for preference cow manure.

The bulbs should be planted 3 or 4 inches deep and 5 or 6 inches one from the other, avoiding treading down the soil. As soon as frost comes they should be well covered with dead leaves or straw, and uncover them when there is no longer danger from frost.

When the tulips, etc., are in leaf, and failing rain, it will be necessary to water them lightly.

Cinerarias.—The various collections of these plants, both double and single, were charming to look upon, a hybrid double of a sky blue, and a white variety, being specially noticeable.

Lilacs.—There were five or six double varieties shown.

Roses were shown in great variety, the more noticeable of Teas and hybrids of Teas being:

Marquise de Salisbury, rose, very elegant.
Lady Alice, rosy white.
The Puritan, sulphur.
Comte de Paris, vermillion scarlet.
Princesse de Broglie, flesh colored.
Marquis d'Aligne, dark brown crimson.
Duchesse de Braganza, canary.
Msme. Honoré Dufresne, dark yellow.
Marguerite Ramet, rose de chine.
Reine Nathalie l'Idéale, hazel.

And among Moss Roses:

Oeillet panaché, rose, leafy white at bottom, striped red, remarkable.
Madame G. Bruant, Japanese.

Besides new varieties named—

Doctor Dor, shaped like a Tea, tinted red.
Doctor Grill, center copper colored, reflecting gold, tinted light rose; back of petals rose de chine.
Blanche Moreau, pure white.
Mouseline white slightly rosy.

Ranunculus, *Primula auriculas*, Stocks, Hyacinths, Ixias, *Syringa vulgaris* (*pyramidas*), and Anemones, were well represented both in cut flowers and plants.

Pansies.—A fine exhibit, and in the grounds were some large beds in great variety (one quite black) and of extraordinary size.

Rhododendrons and *Azaleas.*—These were represented by some excellent plants, which had been forced, but as the second epoch brought them out to perfection they are more particularly described further on.

Camelias Japonica.—There were several exhibited, the plants brought here in tubs, the branches in flower, during transportation, being tied up in strong paper.

Palms and ornamental plants.—The first prize was given to a lot of fifty most attractively arranged in a long bed; a *Pritchardia Pacifica* formed the center, with large *Kentia Phœniciphorium*, *Chamœrops Stauracantha*, and with *Crotons Anthuriums*, etc.; there were ferns and orchids interspersed; and one magnificent *Cattleya Mossiœ* var. *Dallei* with at least twenty-five blooms.

SECOND EPOCH—MAY 24-29.

The second epoch of the series was opened by the President of the Republic on May 24. There were abundant examples of all the flowers in season, and to the enterprise of the Belgians was due much of the fine display of orchids and azaleas.

Azaleas.—The main attraction was some fifty varieties of these plants, a rare and superb collection. They had been transported from Belgium, were perfect in shape, and measured 3 to 6 feet across, only an occasional leaf being visible through the wealth of bloom. Among them were some beautiful varieties recently introduced, such as—

Arlequin, pink edged and flaked white.
Mme. Louis Van Houtte, salmon and white.
Memoire de Louis Van Houtte, bright reddish crimson, center petals doubled.
Rosa Bonheur, white, greenish center.
Souvenir de Fr. Vervaene, white, crimped edge.
Reine de Belgique, white.
Roi de Hollande, scarlet.
Le Remarquable, reddish white.
Bijou de Paris, white with tracings of pink.
Colorans, mauve.
Trotheriana, reddish pink.
General Hartmann, scarlet.
Comte de Kenchore, reddish cream, very curious.
Rembrandt, scarlet.
Cedo nulli, reddish lilac.
Jean Vearvaene, cream-tinged red.
Roi des Blancs, white.
Apollon, Irma, Grandis, Antigone, etc.

In the Trocadero grounds, one exhibitor, Messrs. Croux & Fils, had a fine collection of 159 varieties, the beds bordered with Ericas varies.

Rhododendrons.—Another exhibitor had a large very well arranged group of rhododendrons, azaleas (hybrids de Mollis and Americans) with kalmias and other hardy plants, the whole forming a fresh and beautiful display.

But in the grounds of the Champs de Mars rhododendrons appeared to the best advantage; one exhibitor alone had 250 varieties, the trees varying from 3 to 10 feet in height and occupying some 500 square yards. A fern of the genus *Pteris* was planted underneath, and the border of the beds was formed with *Scalopendium vulgare*. In this immense collection a few of the more noticeable varieties were:

Baronne Lionel de Rothschild congestum roseum.
Elfride, enormous ball of flowers.
Hermans, a very large plant of five hundred or more flowers.
Scipio, 8½ feet high.
The Gem, delecate rose colored, with seven to eight hundred flowers.

After the bloom had gone, these plants remained green and vigorous, serving to adorn the walks and paths to the close of the Exhibition.

Anthuriums were well exhibited, and some new varieties obtained

by intercrossing were superior in size and color to those generally seen; there were fine specimens of—

A. Mirabile.
A. Marie Eugenie, richly colored.
A. Ville d'Angers.
A. Mme. de la Devanage, a beautiful white tinged with yellow.

For seedling anthuriums and seedlings of 1889, a first prize was awarded for the varieties Ville d'Angers, M. Bleu, Mme. de la Devanage, and Ed. André, which showed marvelous cultivation.

Roses.—Of roses, both standard and dwarf, there were two very large displays, the judges placing them as equal. There were tea roses grown from seed and grown in the Maritime Alps; another variety of Tea, called Mme. de Watterville, was curious. A few of the new and more noticeable varieties were—

Oeillet panaché, a new moss rose, striped white, and bright rose color, and among the Teas or Indica—

Baronne de Fonville, yellow copper.
Comtesse de Frigneuse (dwarf), bright canary.
Mme. Cousin, rose purplish, the bottom was a light yellowish white.
Mme. Honoré Dufresne, beautiful deep yellow.
Marguerite Ramet.
Marquise de Vivens.

Gloire d'Olivet and Mlle. Berger were two fine rose trees from l'Ile Bourbon.

And of Hybrids "remontants"—

Alsace Lorraine.
Directeur Alphand.
Eclair.
General Oppert.
Gloire de Margotin.
Abel Carriere, crimson.
Alfred Colcomb, red.
Boieldieu, cherry red.
Charles Duval, scarlet rose.
Comtesse d'Oxford, carmine.
Jules Margotin, cherry red.

Besides Gloire Lyonnaise, new in 1885; Charles Lefèvre, Princess Mary of Cambridge, Mme. Victor Verdier, Celine Forestier, Souvenir d'un ami, etc.

Lily of the Valley or Convallaria majalis—a variety Fortin, was shown, very large and full.

Orchids.—By far the largest and best group of Orchids was arranged by Mr. Peeters of Brussels; of the 450 plants exhibited, while all were good, it would be difficult to particularize more than a few.

Of the *Cattleyas* may be mentioned—

C. Mendelii Morganae, after an American,

C. Mossiae Geominyana, a very bright rose variety with crimson and orange lip and crimson blotches on the sepals and petals, the sepals also having two orange marks.

C. M. Petersei, a finely colored variety, mottled white,

C. Labuata Warneri,

C. Mendelii Mariae,

C. Lawrenceana Cynbidium Lowidnum, with ten spikes of 194 flowers.

A new form of Onsidium near to *O. Forbesii*, but with curiously marked flowers, the yellow like a honeycomb.

Laelia cinnabarina, grown in a cool house, and the same in a warm house were interesting, the cool-grown plant being the better one.

Another fine group of Orchids arranged with palms, etc., was also from Belgium; among them were a fine form of *Laelia elegans*, *Cattleya Mossiae alba Piretti*, and some excellent Odontoglossums, and of rare *Cypripediums superbens* (Veitchii) with 20 flowers, *C. hirsutissemum*, with 10 flowers, *C. candatum*, with 10 flowers, *C. measuresianum*, *C. ciliolare*, and *C. Io*, finely flowered.

An English exhibit consisted of more than 200 plants of *Miltonia rexillaria*, and relieved with Maidenhair formed a beautiful group.

There was also exhibited a new and rare plant called *Odontoglossum miniatum*, rather a large flower, the color rich red, with yellow edge and yellow front lobe to the lip; and in addition three very handsome and valuable *Trichopilia crispa* with 10 or 12 flowers each, some good Phalænopsis, the rare *Vanda Parishii*, *C. Dayanum*, scarlet Sophronitis, *Cattleya citrina*, and many other rare and well-flowered plants.

The cultivation of Orchids for the sale of the flowers has been enormously extended of late, and the following varieties have been found to give the best results; among—

Cattleyas—Trianæ Mendeli, *Lycaste Skinneri*, and the *Coelogyne cristata*, The glass house must be kept at 65° to 70° F. as a maximum, and reduced to 55° when the plants are at rest.

Odontoglossums (requiring much lower temperature, say 58 to 60 degrees).—The *Alexandrae Pescatorei* and *Triumphans*; besides these *Laelia anceps* and *Autumnalis*, *Cyprepedium insigne*; *Cattleya Mossiae*, *Gaskelliana* and *citrina*, *Laelia crispa purpurata*, *Perrini Odontoglossum grande*, and most of the Mexican and Brazilian Oncidiums, flower well and are easily cultivated.

Cypripediums should be kept in a temperature of 72° for maximum and 62° for minimum, and very little water when at rest.

A curious plant called *Genista andreana*, found in 1887 in Normandy, with its crimson and yellow gold color, was effective.

Horticultural decorations of apartments were, in two examples, very well done, canvas sides and roofs forming the rooms, but left entirely open on the side exposed to visitors.

Vegetables and fruits in season were exhibited in great profusion, in the covered passages outside the tents. The exhibits were exposed on oblong banks of earth, sloping from a raised center to either side.

Coniferæ.—Of these there were some fine specimens of *Abies commutata glauca* from the Rocky Mountains, called also abies blue; also *Cedrus Atlantica glauca cærulia*, and in the grounds one firm alone exhibited 565 varieties of the following species:

Abies (picca) excelsa.
Araucaria.
Arthrotaxis.
Biota.
Cedrus.
Cephalotaxus.
Chamæxyparis.
Cryptomeria.
Cupressus Lawsoniana.
Dacrydium.
Fitz-Roya.
Glyptostrobus.
Gingko biloba.
Juniperus.
Larix.
Libocedarus.
Pinus cembro.
Pinus strobus.
Pinus Tæda.
Pinus pinaster and *sylvestris.*
Retinospora.
Saxe-Gothea.
Sciadapitys.
Sequoia.
Taxodium distichum.
Taxus baccata.
Thuya occidentalis and *gigantea.*
Thuyopsis borealis.
Torreya californica.
Wellingtonia gigantea.

THE THIRD AND FOURTH EPOCHS, JUNE 7 TO 27.

These exhibitions call for no particular remarks as to the exhibits within the tents, but outside in the grounds the standard rose trees were in full bearing and presented a fine effect. With some 10,000 specimens of almost every color and variety, the amateur could here find his favorites in luxuriant perfection. Much credit is due to the four or five large growers of roses, who combined to make this grand exhibit. The soil was the best, a rich top dressing covered the ground, and abundance of water for sprinkling was always at hand.

Another interesting group in the grounds was an arrangement on trellises, some 3 feet high, of 27 varieties of *Hedera* or ivy. This vine seems to be universally planted in private grounds here to serve the purposes of screens, and the low or ground variety, for borders of paths in woody shady places. Of other sarmentous and climbing plants, there were some 140 varieties of clematis; 80 rose bushes perpetual hybrids, Hungary and Tea climbers; bamboos 28 varieties; ferns, open-air, some 140 varieties.

A group of bushes and small ornamental trees with striped or colored leaves consisted of—

6 *Acer negundo foliis variegatis*, some 10 feet high.
10 of the same, 6 to 8 feet high.
5 *Prunus Pissardii*, 8 feet high.
20 *Prunus Pissardii*, 5 feet high.
40 *Prunus Pissardii*, 3 to 4 feet high.
65 *Spiræa opulifolia aurea*, clustered.
86 *Cornus sanguinea elegantissima*, variegated; planted as a border.

Another group of 15 kalmias, surrounded with 45 kalmias mystifolia of 12 to 16 inches high ; a group of *Magnolia grandiflora* of some 15 feet high, surrounded with *Laurus, Lusitanica eronymus* Jap., and *Buxus semper vivens argentea nova*, was also noticeable.

Aucubas.—There was a group of 50 plants, with a border of some 50 *Buxus semper vivens foliis argentiis.*

Two groups of ornamental trees and shrubs with persistent leaves contained 450 varieties.

Maples.—There was a fine group of 34 varieties of *Acer japonicum*, and a single specimen of the variety *Polym palmatifidum* some 25 years old.

Still another group of ornamental trees and bushés of caducous leaves embraced 93 distinct kinds, with 435 varieties of the same. A few of them were—

Acer pseudoplatanus.
Alaus imperialis.
Aralia japonica.
Berberis vulgaris
Broussonetia.
Calycunthus.
Cerasus.
Cercis flore albo.
Cercis siliquastrum (Judas tree).
Cornus sanguinea.
Corylus arellana.
Cotoneaster.
Cratægus azarolus.
Cydonia japonica.
Cytisus.
Daphne laureola.
Deutzia crenata.
Diospyros virginiana.
Eronymus americanus.
Fagus castaneifolia (americana).
Forsythia Fortuneii.
Fraxinus excelsior.
Hibiscus syriacus (26 varieties).
Hydrangea (7 varieties).
Herria japonica flore pleno.
Laurus benzoin.
Ligustrum vulgare.
Lonicera (chamœcerasus).
Malus baccata.
Morus alba.
Philadelphus coronarius.
Papulus alba.
Prunus davidiana rosea.
Prunus simensis flore albo pleno.
Quercus robur fastigata.
Ribes alpimum.
Robinia (psuedo-acacia).
Rubus canadensis.
Salix annularis.
Sambucus nigra.
Spirea (25 varieties).
Syringa (27 varieties).
Tamarix.
Viburnum.
Weigelia (29 varieties).

Roses.—Teas, the hybrids of teas, Benga., and Noisettes formed the principal exhibits.

"Edouard Pailleron," large flowers with large petals, of a rose copper color, underneath, shaded bronze.

La Gloire de Libourne, also a large flower of imbricated form, and of a deep yellow canary color, the center being saffron.

Souvenir de Mme. Metral, a beautiful shape of a red cherry color, brightened to crimson and vermillion.

Therése Lambert, also very beautiful, of a delicate red color on a yellowish base; center, gold color.

Among Hybrids:

Doctor Pasteur, of a globular form, of a beautiful bright rose, pink color, blooming well.

Mme. Laurette Messinz is a handsome Bengal, of medium size, bright rose de Chine; at base a yellow copper color.

Among Noisette rosebushes:

L'Abondance was much admired; in opening a light rose color, and flowering in clusters of 50 to 100 flowers.

L'Idéal, good shape, half full, of a metallic yellow and red, shaded with golden tints; very distinct from other varieties.

FIFTH EPOCH, JULY 12 TO 17.

This epoch was one of the most brilliant, the show of flowers and plants being magnificent. President and Mme. Carnot came to visit it, and a lunch was served for them in the Pavilion des Forêts.

In one of the tents was a long bed, many colored, composed of flowering plants, such as scabienses, immortelles, coreopsis, enothères de lamarck, reines marguerites, balsams, phlox, pelargoniums, etc.; another was composed of myrtles, such as *M. communis*, *M. florepleno*, *M. mycrophylla*, *M. grandiflora variegata* which is a beautiful striped leaf; *M. mycrophylla compacta*, with small leaves, genus Pimelia; *M. mycrophylla odorata* and *M. romana* and *tomentosa*, downy myrtles; and there were some fine tea roses arranged back of these.

Another group, in which were helianthas, *Achillea filipendula*, *Aconitum*, etc., and perennial plants for rockwork.

Farther on, balsamines, camelia, hollyhocks variegated, *Phlox semiramis*, with white involucre, *P. Phoebe*, pale rose, minerve, etc., made a showy bit of color.

A fine collection of begonias and petunias.

A novelty of *Pelargonium peltatum* obtained from seed (geranium of ivy leaves), a dwarf plant, vigorous climbing and flowering, besides other varieties. Clementine Theulier, rose flower; Murillo, crimson red, and Jeanne d'Arc, pure white.

Begonias tuberculous, remarkable for development of the petals and intensity of colors.

Pelargoniums zonales in some 200 varieties.

Coleas in magnificent variety.

Caladiums, a beautiful lot candidum, semiramis, and the small argyrites.

Gloxinias and celosies, with plumes of a beautiful violet; of hybrids of the former, there was one collection of 100 varieties.

Ferns.—Some large tree ferns imported from Brazil, *Æsophylla amata*, *Trichopteris excelsa*, *Cyathea cardueri*, etc.

Outside of the tents, planted in the open air and in various beds, were coleas, carnations, pelargoniums, amaranths, celosie, and bal-

sams in 36 varieties, besides *Coreopsis tinctoria*, petunias, capucines, zinnias, mufliers or snapdragon, roses, hollyhocks, white and red, etc.

On a table in one of the tents there was a display of fruits in season. Gooseberries in bunches, and plants of the same opposite, in full bearing; also cherries, melons and grapes; besides were several fruit trees in bearing (the fruit not ripe), such as nectarines, "Lord Napier" figs, yielding three crops a year; plums, "Osborn's prolific," and grapevines bearing the red Frankental and the green Chasselas.

Melons were in great variety, such as the Victoire de Bristol, that resembled a Dutch cheese; Small Sweet of Tours, Pineapple Melon of Mexico, de Cavillon (3 varieties), de Malte d'hiver, Vert Grimpant, Cantaloup (8 varieties), watermelons (3 varieties), "Seikon," etc.

Vegetables abundant and attractive. Lettuce: Beauregard, Frisées de Californie, and l'Ohio; cabbages, cauliflowers, radishes, carrots (small delicate variety), cresses, celery, cucumbers, chicory, squashes, gourds, pease, beans, and many kinds of potatoes.

SIXTH EPOCH, AUGUST 2 TO 7.

This was called a "concours particulier," as were the first, third, fourth, eighth, ninth, and eleventh, to distinguish them from the second, fifth, seventh, and tenth, which were "concours généraux."

The plan of the first group being, to determine between the different species of hothouse plants, only those plants were admitted that it was impossible to present at the "concours généraux."

An extract from the programme will illustrate the "concours particulier," Class 83.

HOTHOUSE PLANTS.

New plants, five competitions.

1. One or many flowering or leafy plants introduced the most recently in Europe.
2. The same, introduced directly in France.
3. Lot of hybrid plants, the parentage being indicated.
4. One or many plants (flowering or leafy) obtained from seed and not yet in the market.
5. One or many flowering or leafy plants obtained from seed and in the market since 1878.

Fine cultivation, four competitions.

1. One or many flowering or leafy plants that good cultivation have brought as near as possible to the maximum of development.
2. From 4 to 10 plants most remarkable for their form and development.
3. The best lot of 20 plants of ornamental leaves.
4. The best group of 20 flowering plants, to whatever category they belong.

Special cultivation, two competitions.

1. The finest collection of 50 flowering or leafy plants, cultivated with a view to supplying the market.
2. The finest lot of flowering or leafy plants, cultivated with a view to supplying the market.

At this epoch there was also a special competition—

1. Between collections of the following fresh fruits, fully ripe: Apricots, almonds, cherries, figs, raspberries, gooseberries, mulberries, peaches, pears, apples, plums, and grapes.
2. Between collections of different fruits (species and varieties) from the country south, and this competition was afterwards continued at the five remaining epochs, adding other fruits as the season advanced.

Lawns.—There were also competitions for the best lawns. The most successful were sown with the English ray grass (*Lolium perenne paceyanum*) small seeds, not extra heavy, but perfectly selected; in the open it grows rapidly, and lawns sown with it in April were quite green May 6, and have remained so through the summer; the cost of the seed was $16 for 220 pounds.

For the lawns in the Trocadero grounds, where there was more or less shade, a mixture of large, heavy grain was sown and lightly covered with earth. The following was the mixture:

	Per cent.
Lolium perenne	30
Lolium perenne, Pacey	20
Festuca duriuscula	10
Festuca rubra	8
Festuca tennifolia	7
Cynosurus eristatus	5
Poa pratensis	10
Poa nemoralis	4
Agrostis stalanifora	6

Afterwards a second sowing of the same mixture but of fine seeds, was made, but not covered, as they germinate better in the light, and the whole rolled heavily; the cost of this mixture was $19 per 220 pounds, and about 100 pounds was considered enough seed for an acre. As some of the seeds of this mixture came up in 10 to 15 days, and others only after 4 or 5 weeks, a good lawn was not expected until after the second mowing.

Lilium.—M. Kasawara, of Tokio, Japan, exhibited some fine specimens of lilies such as *L. auratum*, *L. auratum florepleno*, *L. Datemani* and *L. auratum Parkmani*, besides many *Pharbitis triloba.*

Begonias, grown from seed, were very brilliant, and took first prize, and Lemoine exhibited gladioli and cannas.

Hydrangea.—A bed of these plants was exhibited in the grounds, but they were inferior to similar plants in America. Otaska, *paniculata grandiflora* Mme. Von Siebold, and Thomas Hogg, were the varieties.

Pomegranate trees.—Near one of the public buildings a small path-

way was lined with these magnificent *Punica granatum,* in single and double flowers, red and white, and different leaves.

Ornamental annual plants that were exhibited at each concours, were this time well represented, and Messrs. Vilmorin were awarded first prize for cockscombs (*Amaranths*) *Zinnias, Ageratum raries,* African marigolds of which a new variety is a beautiful lemon color, besides carnations and cut roses in abundance.

Palms and ornamental plants had also a place, of which some *Citrus* were magnificent.

Vegetables in season, covered the beds assigned to these plants; the exhibitors were generally the large dealers in seeds, and the specimens were the finest of their kind.

Grapes and fruits were also exhibited.

SEVENTH EPOCH, AUGUST 16 TO 21.

This exhibit brought out a number of competitors from Belgium as well as France, and was particularly rich in palms, orchids, gladioli, dahlias, coleas, dracoenas, etc. Outside of the tents under shade, were numerous collections of china asters brought in small wicker baskets, with sufficient earth, and planted in beds.

Of palms and foliage plants, the first prize was awarded to a Belgian exhibitor, who fully deserved the award. A coccoloba pubescens, with leaves measuring 2¼ feet across, and anthuriana lancheanum and areca sapida, anthurium Gustavi with enormous leaves, anthurium veitchii, large and leafy, pandanus veitchii, philadendron melioni, philademesion lindeni.

A very noticeable exhibit from a Parisian grower was a collection of 25 maranticea in a variety of shades, some noble palms and cycads, such as *latania borbonico, corypha australis, chamœrops excelsa, phœnix canariensis, kentia australia.*

Of cycads, specimens of *horrida C. revoluta,* and *circinalis.*

The excellent cultivation by the Belgians was further evinced in a group of 15 palms, of which an *Areca sapida* must have been 20 feet in height, with a number of fine fronds; *Livistania oliviformis* was a fine example, also *Kentia Belmoreana, Areca Baueri, Phoenix Andersoni* and *senegalensis, Livingstonia filifera* and *Chamaerops humilis,* all with great wealth of leafage.

Another group of French growth was attractive on account of the number of distinct plants, the chief of which were *Chamaerops sinensis, Areca sapida, Phoenix dactylifera, Pritchardia pacifica, Rhapis flabelliformis, Thrinax argentea, Sabal Blackfurniana,* and among Cycads were *Zamia verracosa, Zamia Lehmanni, Zamia resoluta,* and *Dion edule.*

In a glass case were shown a variety of Bertolonias; the *Rosea ponclatissima* crossed with *Bestoleomia marmorata,* and also with sonerillas, making some beautiful combinations.

There was a collection of dwarf Bouvardia plants in flower; one

named President Cleveland was of a rich red, and a Priory Beauty was fine.

A bank of Dracaenas from Belgium showed skill in cultivation; each variety was represented by a row, and the plants were of a high quality; terminalis, stricta, and amabilis were richly-colored specimens.

Orchids.—The Belgians make a specialty of these plants, and were the principal exhibitors; the first place for the best group of plants was again taken by Mr. A. A. Peeters of Ghent; he had already made a fine exhibit in May. There were Cattleyas in several forms, especially of *C. gigas* and *C. Gaskelliana; C. superba splendens*, richly colored rosy magenta; *C. Dowiana*, several richly colored plants; *Oncidium Lanceanum* and *Odontoglossum Harryanum* were to be seen, and a few plants of *O. Crispum* and of *Miltonia Vexillaria.* A prize was taken for twelve plants showing *Oncidium ampliatum majus*, very full of flower; *Epidendrum prismatacarpum*, with three spikes; *Vanda cerulea*, well-flowered; a very richly colored form of *Cattleya gigas*, and plants of *Anguloa Clowesi, Oncidium dasytile, Odontoglossum bastatum* with a good spike, and the bright yellow flowers of *Cattleya xanthina.* For the two best-flowered recently introduced plants, *Cattleya guttata Leopoldi odorata*, with bright-green sepals and petals, the lip being crimson on the median lobe, and with white side lobes; and *Miltonia vexillaria superba*, deeply tinted with a dark blotch of good size, took the prize.

Besides there were well-flowered specimens of *Oncidium incurvum, Cattleya Leopoldi, Odontoglossum Bictonenses, Cypripedium ciliolare*, and *Cypripedium superciliolare, Cattleya gigas, C. Dowiana, Odontoglossum hastilabium, O. crispum.*

Another Belgian exhibitor (Ghent) showed 30 plants, forming an interesting group. *Cattleya gigas* was a fine plant here, and *Odontoglossum Schliperianum, O. Harryanum, Cyprepedium supercilialare, Oncidium Weltoni*, and with its curiously twisted petals, the showy *O. Krameri*, and *Odontoglossum crispum, vexillarium, Wilckeanum*, etc.

Asters or *Callistephus chinensis*, in beautifully colored florets of rose, violet, and white, and their combinations, were exhibited by one nurseryman in 125 varieties. Many of them had been planted in wicker baskets 10 inches in diameter, sunk in the ground, thus facilitating the transportation of the plants for exhibition.

Gladioli.—A very showy part of the competition was in the collections of Gladioli, one firm exhibiting and offering by catalogue some 350 varieties at prices varying from $3 per 100 for the ordinary well-known, to $6 per 100; for the newest plants of 1888 $29 for one dozen varieties, one bulb of each. African (dark red), L'Ardoise (slaty red), Abricote (salmon); one variety called Protée, valued at $4, is thus described:

Magnifique épi large et serré de très grandes fleurs rose vif; les divisions inférie-

ures sont glacées de lilas, la macule blanche bordée de violet rosé, tendis que les extérieures sont nuancées de rouge cinabre.

Another:

Compte Horace de Choiseul, admirable coloris; superbe épi très compact de fleurs grandes, bien ouvertes, d'un coloris éclatant rouge intenser fortes stries ardoisées, macule blanc lilacé lignée de rouge groseille.

There was noticeable also a hybrid, President Carnot, from Nancy.

New plants: For new plants, *Ligustrum Macrophyllum*, with marginal variegations on the leaves, *Deutzia gracilis aurea*, and *Dimorphantus Mandshuricus*, with leaves of pale green with a white edge, took first place.

Cultivation of Gladioli.—Any rich ground is suitable for gladioli. The bulbs are planted in April and may be also put in the ground during the entire month of May, thus giving a succession of blossoms from July to October. The bulbs should be planted about 15 inches apart and at a depth of from 4 to 5 inches in the ground. A covering of straw is useful to guard against frost or drought. At the end of October, or whenever the leaves begin to turn yellow, the bulbs should be taken up, dried in the open air, and then kept in a dry place, sheltered from frost, for use in the following year.

Begonias.—There was a capital collection of ornamental-foliaged begonias, in all about 100 plants.

Dahlias.—A Paris exhibitor showed 400 varieties of dahlias of good size and fine blooms. This plant is much used in private gardens to form the center of beds, other plants sloping down from it.

Roses.—Roses were shown in boxes in great variety, but the effect of such a form of exhibit is not agreeable, although to the eyes of jurors, criticising each flower and variety, there may be some merit.

New plants.—An importation from the Philippine Islands, *Ærides sanderiana*, blooming for the first time in Europe, was much admired.

Carnations.—While this flower was exhibited to better advantage at the last competition, a bed of a new variety, purple in color, called Baronne de Rothschild, was much admired.

Nepenthes.—Nepenthes were exhibited in variety, the most noticeable being Hookeriana, Coccinea, Curtisi, Ampullacea, Sanguinea, Smithi, Superba, Vitchi, and Morgania. In houses outside the tents, and also in beds, the nurserymen exhibited nepenthes, dracœnas, crotons, and various anthuriums and alocasias, beds of annuals, zinnias, amaranths, cockscombs, etc., the latter of great size. Begonias for bedding were very good, such as Madame Comtois, pale yellow, and *Rosea multiflora*, rose red, of a dwarf small-flowered variety. A patch of *Isotoma axillaris*, with lilac-blue flowers, was attractive, and among asters a cream-colored one is novel.

Aquatic plants.—In the grounds of the Trocadero Gardens a small pond was planted with a variety of aquatic plants and grasses, such as *Nelumbium speciosum*, or lotus, *Nuphar advena latea minor*, *Nymphæa pygmea*, *N. tuberosa* (pond lily), *N. odorata sulfurea*

(yellow lily), *N. caspary, Typha utifolia* (cat tails), *Juncus zebrinus* grasses, *Pontsdoria azurea, Butomus umbellatus, Saggittaria Japonica plena.*

Cockscombs.—Very noticeable were two magnificent beds of these plants, in thirteen colors, of deep red, yellow, and variations approaching to white. One plant measured 2 feet 4 inches across the crown, 10 inches over the top, the height being 1 foot 6 inches. The others seemed nearly as large. The following is the plan pursued in the culture: The seeds are sown in March on a warm bed, and the seedlings are pricked out also on a similar bed. Pot culture is avoided. When frost is no longer to be feared the plants are planted out in well-manured soil and in a warm position, and are freely watered during hot weather. They should last in good condition about four months.

Fruits.—A collection of very fine grapes was exhibited, and most of the vines were in pots, trained on a trellis work, the bunches having as a background white cotton batting; the Black Hamburg, Lady Downe, Chasselas Rose, and Caouch were of high quality, richly colored, and the berries well developed. Another exhibit showed branches of vines, illustrating the early ripening on the cut branches, while those on the branches which were not cut, were still unripe.

Strawberries.—The Alpine variety, growing in large clusters and favorites here, were shown.

Melons.—There were two watermelons from Hungary, one of which weighed 35 pounds.

Apples.—Such as Borowitsky, Calville Rouge, Cellini, Tower of Glamis, Lemon Pippin, Peasgood's Nonsuch, Lord Suffield, Emperor Alexander, Gravinstein, showed excellent cultivation.

Pears.—Such as Clapp's Favorite, Louise Bonne, Williams (Bartlett), Doyenne Bonssouch, Jaryonelle, Souvenir du Congrès, and other well known pears in good examples.

Plums.—Were also good, the Kelsey or Japanese plum exciting much attention, besides Kirke's Victoria, Coe's Golden Drop, and Belvoir.

Peaches.—Mignonne, two kinds; Galande, very large.

The best peaches are grown at Montreuil, and a dealer of that section gives the following list of varieties and the probable time of ripening, viz:

Amsden, 1st to 15th July.
Alexander, 15th to 31st July.
Mignonne (early), August.
Mignonne (ordinary), 15th August.
Galande, 15th August.
Reine des Vergers, end of August.
Alexis Lepère, 1st to 15th September.
Belle Beausse, 1st to 15th September.
Bonouvrier, 15th to 30th September.
Belle Impériale, 15th to 30th September.

EIGHTH EPOCH, SEPTEMBER 5 TO 11.

Ornamental plants, with dahlias, roses, carnations, asters, gladioli, begonias, anthuriums, and nasturtiums, with a few orchids, formed the chief part of this exhibit.

Palms, etc.—A *Livistoniœ oliviœ fornis* was a superb plant some 14 feet in diameter, and a *Kentia Forsteriana* was very tall and graceful. Of *Cupressus Lawsoniana cœrulea argentea* there were six healthy plants about 3 feet high grown from seed. *Arancarria Napoléon Banmann* was some 12 feet high.

Dahlias, were, most of them, arranged as cut flowers in cases about 3 feet square, and in the different exhibits of double and dwarf double varieties, there was hardly a choice. One small double variety called "veridiflora" was entirely green. Among novelties, like cactus flowers, were "Empress of India," a dark reddish-brown, growing lighter toward the outer edges; Aster, rose; Roi des Cactus, crimson; Étoile du Diable. Of Mexican dahlias (single) there were 70 varieties of cut flowers exhibited in boxes.

Roses.—A Belgian firm from Luxembourg made a handsome exhibit of cut flowers, and advertised 190 varieties of roses, covering 30 acres of land. A French grower had 150 varietes of roses cultivated in pots (standards, half standards, dwarfs, and seedlings), a form of cultivation highly recommended as giving an assured result; the following are some of the names of the new tea roses:

Comtesse Anna Thun, yellow orange.
Duchesse d'Auerstadt, large petal.
Edouard Pailleron, rose copper, shaded lively yellow.
Elie Beauvilan, whitish, red veins.
Glorie de Libourne, canary.
Agathe Roux, rose.
Clarie Jaubert, yellow.
Jeanne Cuvier, dark rose.
M. Hoste, yellowish white.
M. Joseph Godier, pink rose de chine.
M. Max Singer, yellow-shaded orange.
M. Philemon Cochet, very light rose.
Mlle. H. de Beauvau, light yellow.
Magdeleine Beauvilain, light yellow.
Miss Lizzie, light yellow.
Monsieur Rosier, rose yellowish, white center.
Princess de Sagan, velvety crimson.
Souvenir de Mr. Metsal, red-shaded cherry.
Therese Lambert, red, center gold color.
Viviene Morel, crimson red, shaded poppy.

Besides hybrids of teas, such as—

Docteur Pasteur, rose carmine, shaded deep red.
Jules d'Assonville, lilac rose.

There was a Bengal rose called Laurette Messing, rose de chine

brightening to yellow copper, and a Polyantha, flowering in enormous clusters, of a yellow Nankin color.

Of hybrids (remontants):

Albert la Blotais, deep-red crimson.
Auguste Perrin, cherry, with violet lights.
Job Bardou, velvety scarlet, almost black.
Conseiller Stockert, rose.
Duc d'Audiffret-Pasquier, purple red, deep center.
Duchesse de Galliera, rose carmine.
Directeur Tisserand, deep-carmine crimson.
François David, red and velvety crimson.
Gloire de Margottin, cherry red.
James Bougault, white, rose tinted.
Katkoff, cherry red.
L'Ami Loury, crimson purple, like velvet.
Louis Lille, deep red.
Madame Alphonse Seux, light rose.
Mme. Cesar Brunier, rose de chine.
Mme. Charlotte Walter, satiny rose.
Mme. Heine Furtado, rose, lilac shades.
Mme. Richaux, light rose.
Mme. Sophie Stern, light rose, metallic reflections.
Marquis d'Aligre, red vermilion, brown shades.
M. Chevallier, cherry red.
M. Jourdan, purplish red.
M. Niogret, brilliant red, purple center.
Morphée, deep-red crimson.
Pierre Liabaud, reddish purple, velvety.
Prince Charles d'Arenberg, rose carmine.
Reine Isabelle II, light red.
Roi François d'Assise, dark red, violet shades.
Scipion Cochet, reddish maroon.
Souvenir de Mme. Faure, crimson, shaded with purple.

And a moss rose (Chevreuil), large, globe-shaped, of a satin-rose color.

Carnations.—Dwarf variety called Tige de fer. There were some 300 varieties, cultivated in pots, and flowering abundantly. In late autumn and winter, by moving the plants into a hotbed frame or cold house, the plants will continue to flower, and the infinite variety of shades and colors make this a most desirable plant for the amateur.

Reine Marguerites, or China asters, in some 60 varieties, half dwarf and dwarf.

Nasturtiums.—Capucine Grande, grown in pots and trained up some 5 feet high. There were 30 varieties, mostly of cardinal-reddish shades, with a few light canary and golden yellow,

Begonias.—Single flowers grown from seed in 1889. There were several varieties.

Pineapples.—Several plants with fruit of large size, apparently in great perfection. When served at table a custom prevails to bring in the plant and then and there cut off the fruit. Smooth Cayenne and Charlotte Rothschild were the varieties.

Orchids.—A few lots were exhibited among the ornamental plants. Some fine specimens of *Cattleya gigas, Oncidium lanceanum, Catasetum Bungerothi,* and a profusion of *Odontoglossum grande,* with enormous flowers of yellow spotted purplish brown; also *Ledia elegans, O. Uroskinneri, Oncidium tigrinum* and *varicosum, Vanda cœrulia, Cyprepedium io* (hybrid), and, as botanical curiosities, the *Lissochilus Krebsii* and *Philidota imbricata.* In one of the hothouses is a specimen of the *Cerides sanderianum,* with fine, enormous bunches of flowers, certainly one of the most remarkable orchids exhibited.

VERSAILLES FLOWER SHOW.

On August 24 I visited a flower and fruit exhibition at Versailles, held under the auspices of the Horticultural Society of the Seine-et-Oise Department.

It was comprised in a large circular tent, and appeared to interest very particularly the owners of private gardens in the neighborhood, most of whom were present to congratulate one another on his or her exhibit. Such competitions would seem to give more zest to the cultivation of the garden in private grounds, than the larger shows of nurserymen, who grow only for market.

There were several examples of *Retinospora obtusa gracilis nana,* a small Japanese evergreen of a beautiful shade of green. Dracœnas in great variety, such as Poubelia, Cte. Kergolay, etc., also cannas, crotons, caladiums, gloxinias, and clematis. Of the latter, Gigantea (white), La France (purple), Ville de Paris (white), pink center, and a new variety called "Cocinea," were the more noticeable.

Outside of the tent were exhibits of pears, peaches, plums, apples, nectarines, grapes, etc., arranged in plates on tables. In beds on the ground were many varieties of fine vegetables; also exhibits of simple kinds of stove and hot-water heating apparatus, comparatively inexpensive, also utensils for the garden.

Entrance the first day was reserved for members of the society, and to others on payment of $1. The second day, tickets were reduced to 20 cents.

NINTH EPOCH, SEPTEMBER 20 TO 25.

Of the two exhibition tents, one was devoted to plants and flowers, and the other to fruits, while vegetables were arranged in two covered walks in the grounds near by.

Dahlias.—Double and Lilliput were exhibited in the usual variety, arranged in square cases set off with moss, each variety distinctly labeled.

Triomphe d'Alger, deep red.
Empress of India, brownish red.
John Forbes, red, lighter on edge.
Paoniner, reddish deep brown.
Jeanette, canary.
Gracilis, striped.

Roses.—Some 20 cases in variety, chiefly teas.

Caladiums.—There was a good show of these plants.

Marguerites, or *Aster sinensis*, were represented by a well-selected lot of healthy plants.

Orchids.—Some 20 plants in flower: *Odont. Grande* and a new *Phalaenopis Dachartrii*, with a small purple flower 10 spikes, besides the magnificent *Cattleya aurea*, and *Cyprepedium insigne, barbatum, collusum, spicerianum*, etc.

Gladiolus.—Still a few.

Begonias—Pœonia coralina, resembling coral with black berries, were a showy lot of plants.

Cyclamen pensicum, variety *superbum*, produced from seed sown in September, 1888.

Carnations.—Perpetuals made the best effect in the show, there being several large beds.

Geraniums.—In several colors, Charles Foncard, scarlet, etc.

Dracoena Lindeni, with its leafy yellow and green.

Fruits.—The fruit show was remarkable for the extent and quality of the exhibits. There were 3,416 separate samples of pears, 2,350 samples of apples, and 488 samples of peaches. Most of them were arranged five on a plate, but here and there were baskets of one or two dozen each of these fruits.

On the labels or cards, one large grower of fruit trees had the name of the variety, and lines for month of maturity, quality, and remarks printed on them. The following are a few of the varieties:

Apples.—

Grand Alexandre; red; one sample measured 14½ inches circumference.
Rambour d'Amérique; deep red; equally large.
Peasgood Nonsuch; large yellow.
Reinette Etoilée; red, winter.
Reinette du Canada; green, sweet, winter.
Reine des Reinettes; a great favorite; orange red, winter,
Calville Blanc.
The Queen.
Celestin.
Belle Dubois.
Framboise; like Gillyflower.
Hawthornden; yellow,
Reinette d'Amérique.
Douce d'Amérique.
Apirose; small.
Lehigh.
Newton Pippin; greenish, red on one side.
Downton Pippin.
Warwick Pippin.
Red Fall Pippin.
Green Pippin.
Wormsley Pippin.
New York Pippin.
Linneous Pippin.
Cox's Orange Pippin.

Greave's Pippin.
Ribston Pippin.
Missouri Pippin; small.
Blenheim Pippin; reddish.

Pears.—
Seckel; one sample only.
Duchesse d'Angouleme; large.
Clairgéan; large, long.
Beurré Diel.
Belle Angerine; enormous.
Duchesse d'Hiver.
Triomphe de Jodoigne.
Doyenne du Commerce.
Charles Ernest.
Epine du Mas.
Beurré Superfin.
Columbia; large, green.
Bonne Chrétien d'Espagne.
Colmar á Aremberg.
Louise Bonne d'Avranche; scarlet; fine effect.
Duc de Bordeaux.
Beurré Bachelier.
Beurré Gris d'Hiver.
Beurré Lebrun.
Thompson.
Van Marum; long russet.
Bon Chrétien Williams (synonymous with the Bartlett of Boston, propagated in 1777 by Williams, a London horticulturist).

Peaches.—
Alexy Legére.
Belle Impériale.
Bourdinne de Narbonne; very large.
Chevreuse Tardive.
Belle Beausse.
Galande Moire.
Empress Eugénie.
Princess de Galle.
Stump the World.
Aigle de Mer.
Suthampstead.
Exquisite.
Blanch d'Amérique.

Nectarines.—
Victoria.
Bowden.
Magnifique de Padoue; deep yellow and red.
Standwich.
Violet Musqué.

Quinces.—There were eight varieties:
d'Algiers.
Portugal.
Orange.
Musque Champion.
de Constantinople.
De Bourgeons.

Grapes.—Both hot-house and open-air grown grapes were exhibited. Many of the bunches were still attached to sections of the vine, which had been cut off and the ends immersed in vials of water. The Chasselas Rose and Dore of Fontainebleau were shown in abundant samples. Besides were:

Black Alicante, }
Lady Downs, } very large.
Gros Colman, }
Muscat d'Alexandrie; white.
Gros Maroc; purple.
Golden Champion; white.
Gradista; white.
Schiradyoulti; long white.
Valencia; long.
Frankenthal du Bunden; large, long.
Chasselas Duhamel; white, transparent.
Chasselas de Negropont; purple.
Cornichons; long white.
Cornichons; a black variety.

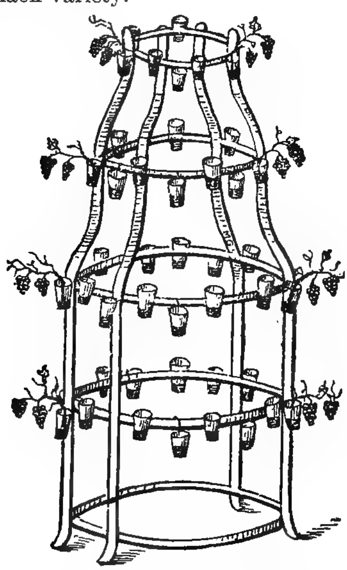


FIG. 2.

M. Salomon, of Thomery, near Fontainebleau, exhibited some 150 varieties of vines grown in pots, all in full bearing, the fruit being in different stages of ripening. All these had been grown under glass with more or less artificial heat. These hot-house cultivated grapes are not at all plentiful in the Paris markets. The demand is supplied by open-air fruit from Algeria, later from the south of France, and in October there is an abundant supply of the small, much-prized Chasselas from Thomery and the neighborhood.

Salomon's apparatus for keeping cut grapes fresh is shown in Fig. 2.

TENTH EPOCH, OCTOBER 4 TO 9.

In two corners of one of the tents were 20 trees about 10 feet high of *Cratœgus pyracantha lalandii*, at this season covered with red berries the size of small cherries, very ornamental. Also 40 plants of hybrid *Dracœna indirisa*, remarkable for their development, besides *Cycas Tonkinensis, Cycas siamensis* (sago), and a beautiful collection of *Areca sapida*. There were 3 fine specimens of *Abies Engelmani*, grown from seed.

The *Damara australis* was curious as having no twigs, the leaves springing from the trunk and branches.

Carnations (*Tige de fer*).—There were two beds of these plants in flower, each 50 feet long by about 7 feet.

Begonias.—Plants and cut flowers in scarlet, pink, white, yellow, rose, the double variety "Reine Isabelle," pomegranate red, and striped, showing excellent cultivation.

Dahlias.—Cactii and dwarf varieties, much resembling the previous exhibit.

Mignonette (*Resida odorata*), grown from seed sown in July was in full flower.

Chrysanthemums.—There was a small exhibit of some 20 varieties (cut flowers).

Roses.—M. Levèque & Son had nine cases of various kinds, and there was a bed of dwarf hybrids of teas.

Dracœna amabilis, green and white, and *Dracœna terminalis*, red and green, were represented by a mass of foliage.

Latania borbonica was a fine palm here.

Vriesea brachistachi.—There were 12 of these curious orchid-like plants.

Dwarf orange trees with myrtle leaves, and *Bigarade ordinaire, Bigarade turcos.*

Marigolds, dwarf variety, yellow, gold, the same with brown center, dwarf brown, and striped.

Aster horizontalis, borei, tradescentum, formosissimus, prealtus, moulinsii, roseas tubinellus, formed a good background for a multicolored bed of primroses, poppies, begonias, dahlias, salmia, cockscombs, zinnias, marigolds and anemones.

In the grounds a handsome bed of flowers in season was composed of one or more specimens of Reine marguerites, petunias, amaranths, marigolds, *Callinsia bicolor Linavia multipunctata erecta*, lobelia, *Alysee* (dwarf) *compactum, Brachycome iberidefolia, Perilla de Nankin*, nasturtiums, sanci (double).

In one of the tents, arranged on 8 rows of shelves, Messrs. Jorgeot & Co. had 1,500 samples of seeds in inverted flat glass bottles, properly labeled.

There was a model in miniature, about 10 square feet, of an apple

orchard. The distance between each tree was suggested as $15\frac{1}{2}$ to 18 feet, according to the richness of the soil.

Fruit, such as pears, apples, grapes, etc., were exhibited much the same as in the last epoch, but in a much smaller number of samples, except, perhaps, the grapes.

Vegetables, especially potatoes, were in abundant samples and varieties.

Grafts.—In the agricultural department there was exhibited practical examples of the many forms of grafting in use in France.

ELEVENTH EPOCH, OCTOBER 18 to 23.

This was the last of the regular horticultural competitions, and the principal exhibits were fruits and vegetables, with a few flowers and ornamental plants. Fruits (class 81) brought out 34 exhibitors, and vegetables (class 80) had but 10 exhibitors.

Chrysanthemums.—While not large, the exhibit of these flowers was remarkable, M. Phatzer, of Luxembourg (Nord), showing some 32 varieties of great size and beauty. Many of the flowers measured 6 inches across and curled over in beautiful colored balls. From the great success of M. Phatzer in bringing these flowers to perfection, and of the varieties giving the best results, some useful extracts are here given, taken from his publications.

Out of the 107 novelties produced by seed in 1888, he had selected 33 as having given thoroughly satisfactory results, viz:

Anatole Cordonnier, purple.
Comte Foucher de Careil, violet and white.
Joseph Marvet, copper yellow, with red tips to petals.
Cuthère, velvety red.
La Tosca, rich red, shading to black.
Mr. Bergman, brilliant yellow.
Mr. Louis Langlois, old gold, edge of petals deep red.
Mr. Constant Varin, gold center, rose tipped.
Mme. Mézard, rose violet, with white tips.
Mlle. Andrea Mary, brick red. long petals.
Sabine, yellow, cream center.
Nelson, rose violet, light center,
Anatole Cordonnier, light rose, gold center.
Philippe Lacroix, rose and white.
Avocat Jaffary, rosy white, long petals.
Mme. Gros, light rose, white center.
Souvenir de M. Bredy, violet and rose.
Mr. Antonie, brilliant yellow, underside of petals red.
Ferdinand de Lesseps, carmine, underside white.
Mr. Antoine Berges, white.
Dr. Jeanbernat, red, gold center.
Rabelais, rose and white.
Mr. Jules Lefevre, dark violet, underside white.
Mme. Duchesne, white.
Souvenir de Victor Dalanroy, deep red.

Gustave Nadaud, white, changing to rosy lilac.
Souvenir de Alfred Motte, red, with outside yellow.
Fred Hart, deep red, center changing to creamy white.
Mr. Bérat, magenta.
Mme. Pynaert van Geert, dark red, lighter center.
Mr. Willem-pere, yellow.

Mr. Phatzer presented also a treatise giving the results of his experience in their cultivation and explaining what he considered the most satisfactory method to pursue.

He recommends as the most suitable composition of soil for the preliminary potting, two-thirds leaf mold and one-third good garden soil mixed with sand.

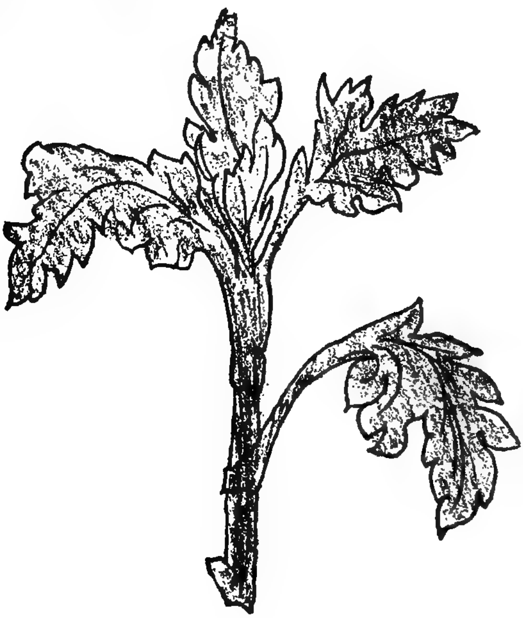


FIG. 3.

Before commencing the formation of plants by means of slips, it is important, he says, to decide exactly what result is sought for and then adopt your method.

If it is wished to have strong plants for the conservatory, or flowers of great size, it is necessary to commence operations towards the end of January, continuing until the end of February.

If, on the other hand, the object is to obtain plants of moderate size and abundance, rather than the quality of the flowers, then it is better to operate a month later, by which means small, sturdy plants will be obtained.

The first step is to make a proper choice of slips, selecting only such plants as have proved in every respect satisfactory.

Figure 3 shows the best slip to choose, cut below a leaf and $2\frac{1}{2}$ to 3 inches long. All those having a bud should be rejected.

The other details are the same as in all raising of plants from slips, with the warning that the chrysanthemum being a plant by its nature hardy, it is much better to leave these slips to sprout in a cold bed than in a hot one. At the end of four weeks the first roots commence to develop, when it is advisable to give the plants a little air. At the commencement they require only water enough to keep the stalk firm. When the plant commences to develop great care should be taken that, whilst giving as much light as possible by bringing it close to the glass of the house or bed cover—always kept at a low temperature—it should not be overheated or overwatered.

When the roots have so developed as to reach the borders of the flower pot, it is time to repot, which should be done in a soil composed of 2 parts good fresh earth, 1 part leaf mold, 1 part horse manure almost reduced to mold, with a little sand added. Four-inch pots should be used. Treatment about the same as before, as far as giving light and avoiding any excess of heat.

When again the roots have well developed, the pots are changed to 9-inch, and finally the well developed plant is potted for flowering in soil composed as follows, viz: 4 parts fresh garden soil, 1 part leaf mold, 1 part mold from old manure, 1 part sand, ½ part wood ashes.

An amateur exhibited 21 varieties of chrysanthemums (cut flowers) showing good cultivation.

Foliage plants.—There were two large beds of palms in variety.

Carnations.—Two beds of healthy looking plants, flowering well.

Begonias.—A small collection, well arranged, of cyclamens. A Copenhagen grower sent ten plants in flower, grown from seed.

Roses.—There were nine cases of cut flowers, and a small bed of dwarf tea roses.

Gunnera scabra.—There was a large specimen of this leafy plant.

Pernellia.—There were eight of these very pretty plants, with differently colored berries, such as *alba*, *carnea nana*, *purpurea macrocarpe*, etc.

Dahlias.—In the grounds Mr. Paillet had a bed some 130 feet long of double and single dahlias in great variety; the plants were at this date in full bearing and very vigorous.

Vegetables.—A list of those exhibited included lettuce, chicory, beans, radishes (twenty kinds), cauliflowers, cabbages, onions, carrots, salsify, shalott, tomatoes, celery, cucumbers, egg plants, leeks, artichokes, turnips, beets, potatoes, pumpkins, spinach, dandelions, stachys (crosnes of Japan), squash (one measured in length 4 feet), peppers (several varieties), buccoli, squash of Portugal (light coral color), onions of Maderia (one 18 inches in circumference), white egg plant, small pumpkin of China, Cardon d'Espagna, giant celery root, cherry tomatoes, sweet potatoes (one sample from Algeria), yam from Algeria, colocynths in variety, melons, (olive

d'hiver, new) cantelope, de caraillon, de Malte d'hiver, okra, or *Hibiscus esculentus* (a few insignificant specimens).

Fruit.—Specimens of apples used for making cider, assorted; first season of trees bearing forty varieties; second season of trees bearing fifty varieties; third season of trees bearing forty varieties. These were each labeled with printed cards, the description being filled in by writing, *e. g.:*

> Name or variety, Genlis.
> Blossoming, May 20.
> Fertility, great.
> Rusticity (*i. e.*, quality to resist inclemency of the season), medium.
> Form of tree, branches reascending.
> Nature of soil, sandy.
> Savor of fruit, sweet.
> Observations, makes an excellent cider.

Another exhibit was from the Province of Gueldre in Holland, eighty new varieties grown from seed, of mostly bright yellow looking apples, trees planted in a dry and sandy soil "au sujet du système du feu M. L. de Bouttervide de Rouen à l'égard de l'existence limitée et de l'extinction des végetaux propagés par division. (According to the principle of the late Mr. L. de Bouttervide, of Rouen, who maintained the principle of the limited existence and gradual extinction of plants propagated by separation.)"

There were many other samples of this fruit, including the Baldwin, but not at all like ours of the same name.

Pears.—Many samples of qualities suited to making perry; others so-called "Poire ā couteau," maturing January to March, such as Bergamotte Fortuné, Gendron, Doyenne d'hiver, Prince Napoleon, Beurré Bronze, St. Jean Baptiste, besides many baskets of the beautiful Duchesse d'Angouléme, Fondante des bois, Bel Angevine; of the latter, one specimen exhibited weighed 2 kilos 700 grams (nearly 6 pounds).

Persimmons (*Diospiros, Kaki of Japan*).—There were some fifty samples of this excellent fruit which had been grown at Hyères (Var), in the extreme south of France.

Pomegranates from Algiers.

Arbouse, a sweet fruit resembling a strawberry in appearance, also from Algiers.

Grapes were exhibited in great perfection.

Prizes.—Group IX received one grand prize, thirteen gold medals, fifty-five silver medals, sixty-five bronze medals, sixty-eight honorable mentions; making two hundred and two recompenses for three hundred and twenty-seven exhibitors.

UTILIZATION OF SEWAGE.

In the report of Mr. Campbell on the Exhibition of 1878, reference was made to the subject of the utilization of sewage refuse in the neighborhood of Paris, as a fertilizing agent. At that time the effort was hardly more than an experiment. A hotly contested bill was passed some six months ago in the French legislature, by which the field of operations has been very much enlarged.

The locality where the preliminary trial has been made (a still earlier experiment on a small scale had been made at Clichy in

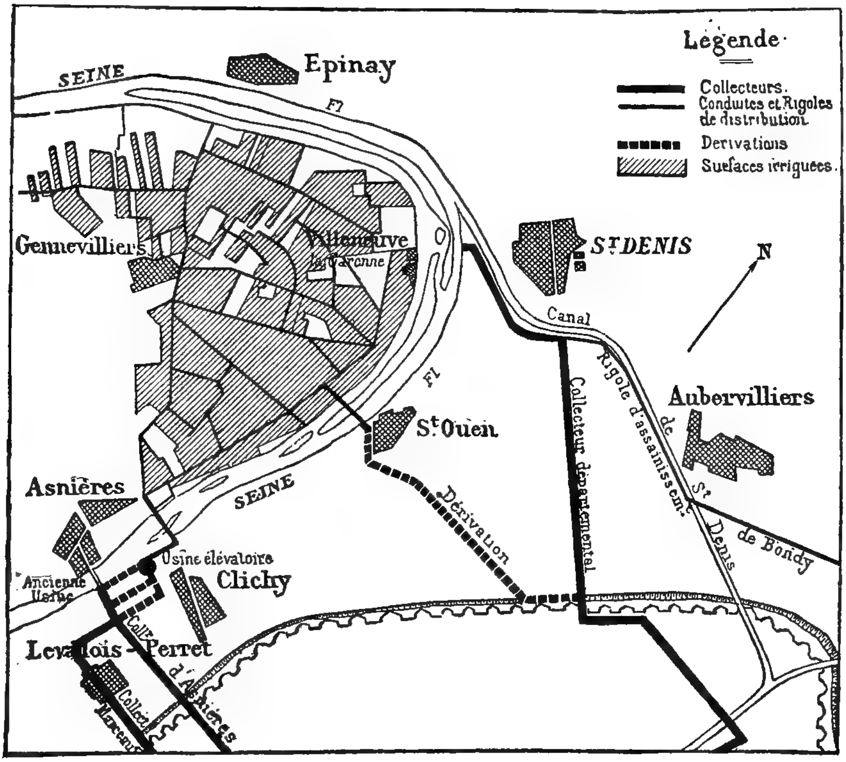


FIG. 4.

1867–'68), Gennevilliers, near St. Denis, is in the immediate neighborhood of the place where the great Paris sewer empties into the river Seine. (See Fig. 4.) It is now proposed to divert a further portion of this sewage through a large tract of sterile land, situated on the borders of the Forest of St. Germain, and occupying a position on the river similar to that at Gennevilliers; it is in a corresponding bend some miles farther down, but at a comparatively short distance across by land, the river winding very much at this part. This locality is known as Achéres. (Fig. 5.)

The prime object of this diversion of sewage was an effort to purify the water of the Seine below Paris, the pollution of which, was becoming more and more a source of real danger to the inhabitants of the many towns and villages on its banks.

Analysis had shown that the ordinary sewage water of Paris contained some 80,000 microbes to the cubic meter, and, as it was proposed to adopt the system known as "everything into sewer," it was

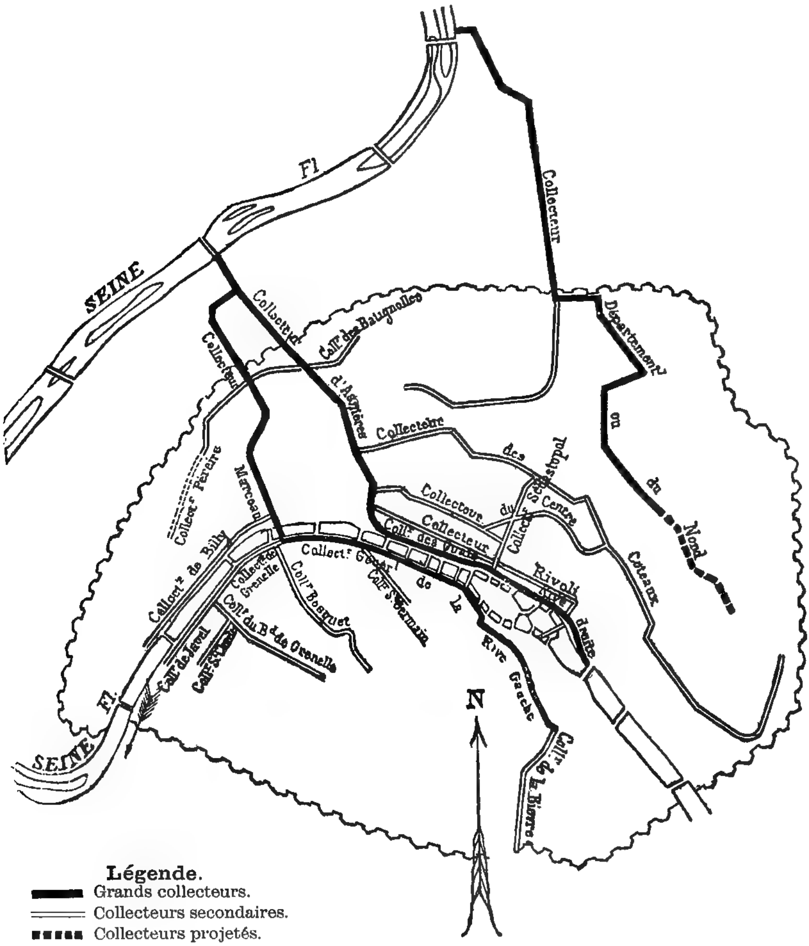


FIG. 5.

still more urgent to find a remedy. As for the danger to health of the inhabitants of the district where the system was in operation, the results of experience at Berlin and elsewhere, prove that it is more fancied than real.

For the purposes of filtration, a sandy soil mixed with gravel is the best, and this need not have a greater depth than 3 feet. A chalky soil may likewise be used to advantage. The process of

nitrification of the matters in solution, which are mainly arrested on the surface, is extremely rapid, and it has been shown by experience that the microbes present, do not escape with the drained water.

The richness of this sewage in fertilizing matter. is shown by the following analysis of a cubic meter of water:

	Grammes.
Azote	45
Phosphoric acid	18
Potash	37

which is much richer than ordinary farm manure.

Supposing that this water were to be simply poured over a surface for the purpose of filtration, it would even then be necessary to work the ground from time to time, in order to facilitate its passage, and prevent the formation of pools; consequently the trouble and expense would be great, and all this valuable fertilizing matter would be lost. It was decided, accordingly, that the point chosen should be one that permitted the utilization of the sewage for agricultural purposes, as well as offering facilities for filtration.

The method of irrigating is as follows: The water is brought to the fields by means of ditches, with sluices at intervals, so as to

FIG. 6.

have complete control over the distribution; it is then either allowed to flow entirely over the ground, or in the case of vegetable cultivation, the ground is cut up with shallow channels which receive about 4 inches of water, and on the spaces between the vegetables are cultivated. (See Fig. 6.) The ground most of the time is drained. The water is let in as often as it is thought necessary to secure the best result, but as a rule an interval of at least four days is allowed between each irrigation.

In the case of meadow land, the reservoir is formed at some point higher than the general level. The water is allowed to flow slowly over the field, care being taken that the liquid does not reach the part of the plant that is to be cut. This is especially advantageous in summer. Ray grass or *Lolium Perenne*, *Dactylis glomerata*, *Holcus lanatus* (dactyle et le houlque) succeed the best.

For cultivating grain, the ground is inundated several times; the deposit is then worked in with the plough. After the grain is up, the irrigations are discontinued, unless necessary during the summer to counteract the effects of drought.

Cultivation of almost every nature is found to succeed admirably.

Meadow lands, the cereals, all the plants of the kitchen garden, strawberries, and fruit trees, profit equally well, and the results

have been so satisfactory that the rental value of such lands has increased tenfold. As much as 39 tons of sugar beet have been produced to the acre. The gross receipts vary between $240 and $800 an acre, and the rental is as high as $80 per acre.

Notwithstanding the considerable amount of matter which is thus added to the soil, very little is found to remain in a fixed condition, and the ground loses in no perceptible manner its porous qualities. The meadows in the neighborhood of Edinburgh, which have been treated in this way for 80 years past, remain comparatively poor in azotic matter.

This system is now employed in the following places: Barcelona, Valencia in Spain; Lausanne in Switzerland; Berlin, Dantzig, and Munich, in Germany; Budapest, Athens, etc., and in France at Poitiers, Montelemar, Reims, St. Leonard, etc. In Great Britain, it has been adopted in many towns for a long time.

In one of the horticultural departments of the Exposition, was shown a model kitchen garden, conducted on this method, the water being pumped up from the sewer.

To obviate the inevitable accumulation of water below ground, a careful system of drainage has been established, by which the water in a condition of perfect purity is carried to the river Seine.

An official inquiry established the following facts, as regards the production of vegetables at Gennevilliers by the acre:

Artichokes	heads	40,000 to 60,000
Cauliflower	heads	16,000 to 24,000
Garlic	pounds	28,000
Carrot, over	pounds	100,000
Celery, over	pounds	80,000
Cabbage, up to	pounds	112,000
Onions	pounds	48 000 to 64,000
Leeks	pounds	48,000
Potatoes	pounds	24,000 to 28,000 and 32,000
Pumpkins	pounds	90,000 to 100,000
Salsify, over	pounds	20,000

The amount of water to be used over an acre during a year is limited by the law of 1888 to 390,000 cubic feet.

HOTHOUSES AND CONSERVATORIES.

The hothouses and conservatories were principally situated alongside of, or on a line with, the great show tents for flowers and fruits; these were parallel with the river, and with them served as a place for exhibition, especially in the case of rare and delicate plants; at the same time they were, themselves, models of every variety of form and construction of which such buildings are capable, and almost every important house, engaged in the manufacture, was represented in some form or other.

Commencing at the extreme west end of the Trocadero Gardens, the first examples were ingenious, simple, and inexpensive constructions, in the shape of movable forcing houses (Figs. 7, 8, and 9); whether used as permanent against any wall, placed over an existing hotbed, or moved from place to place along the face of the

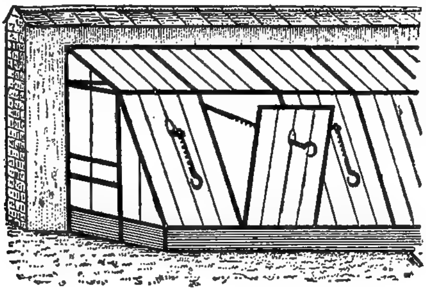


FIG. 7.

wall they stimulate the maturity of the "espalier" fruit. Beyond these was a much more ambitious structure, viz, the splendid grapery of Salomon of Thoméry, near Fontainebleau, constructed by A. Coulon, of Alsace, measuring about 114 by 33 feet. It contained on each side of a broad central alley, two rows of grapevines of various species in pots, trained vertically, and other vines planted in the ground and trained against the glass covering; in the spaces between was a triple row of hot-air pipes on both sides. These vines were in splendid condition and well covered. The annexed illustra-

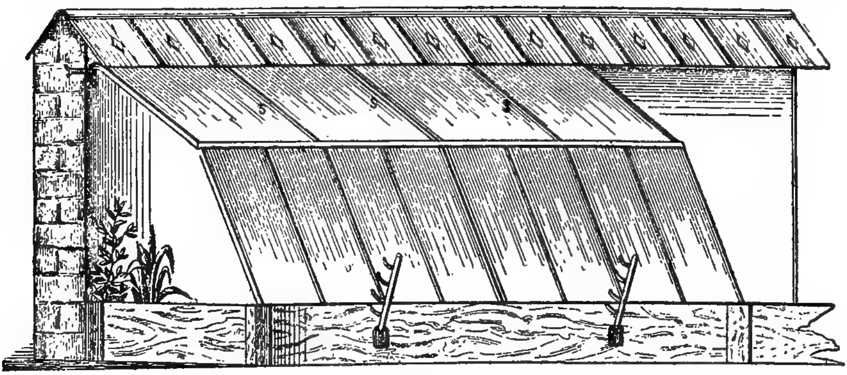


FIG. 8.

tion, Fig. 10, although only arranged for four rows of plants, is constructed on the same system. The heating was according to the method of A. Ricade, of Versailles.

Then followed four hothouses, each being of similar dimensions, and all of the type known here as a Holland hothouse, the feature

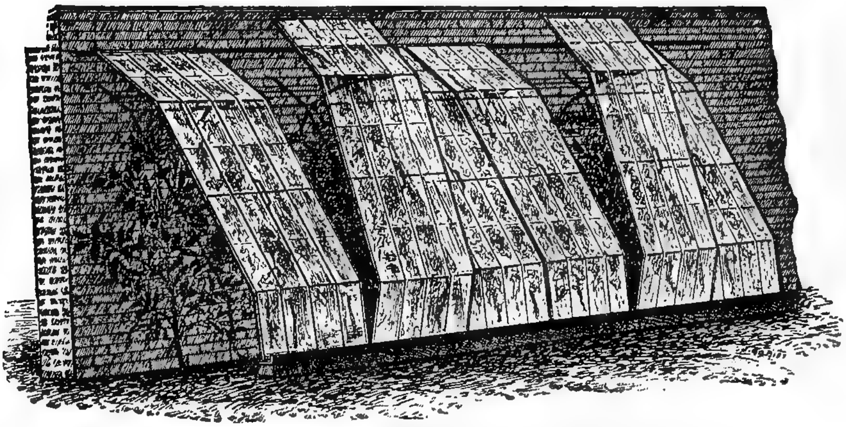


FIG. 9.

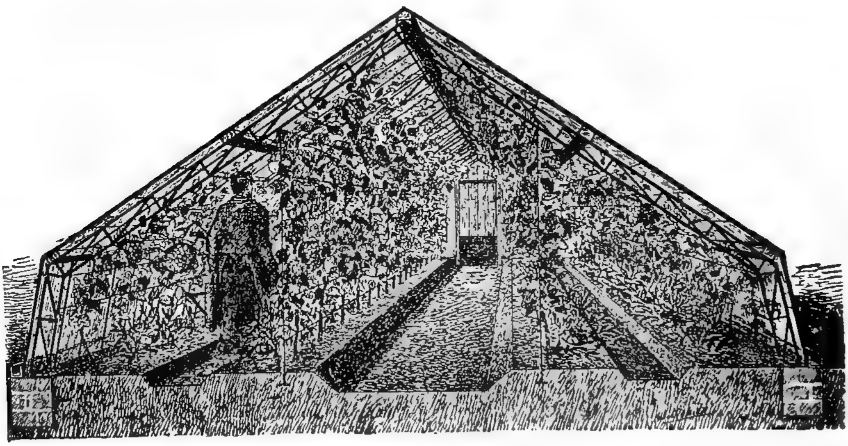


FIG. 10.

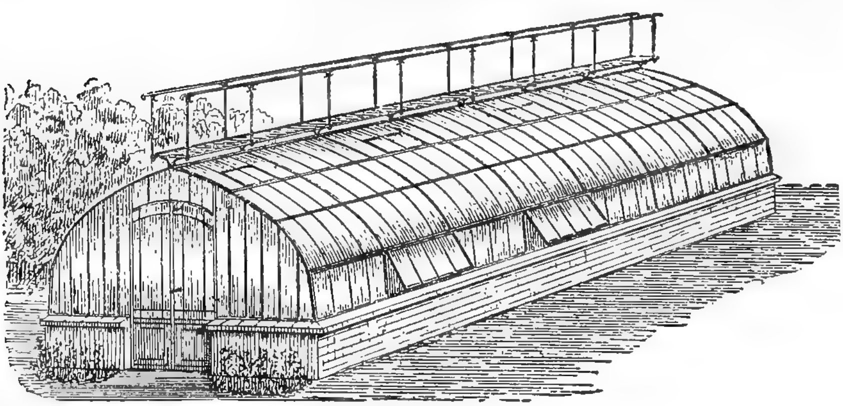
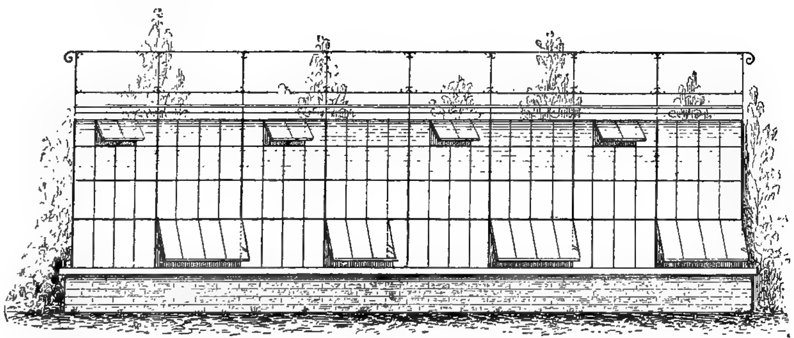
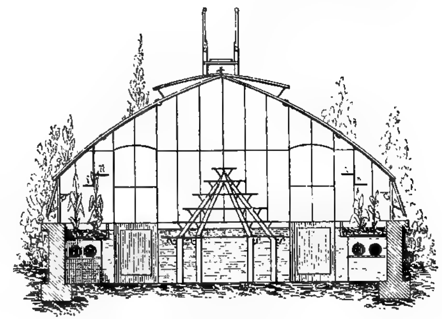
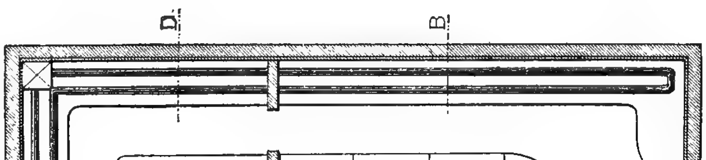


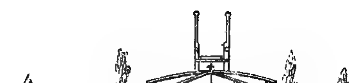
FIG. 11.

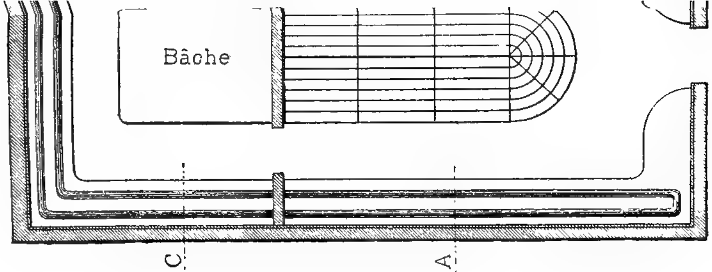




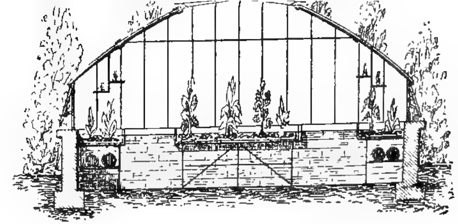
Section AB



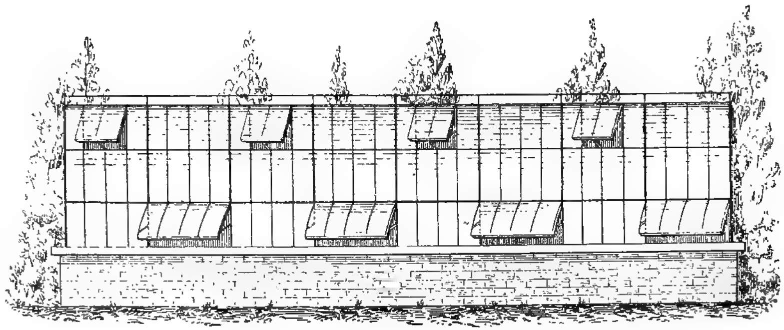


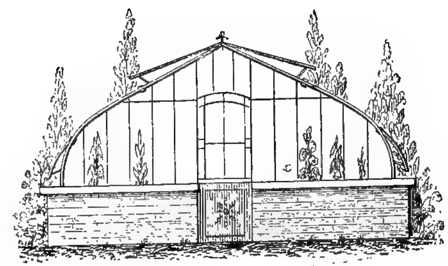


Plan.



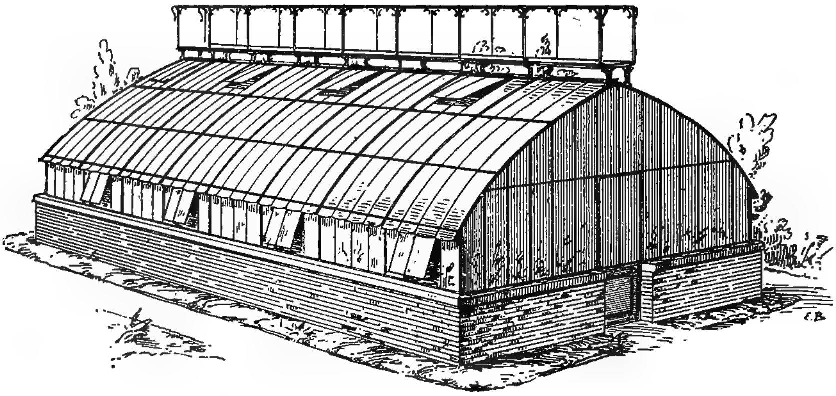
Section C D

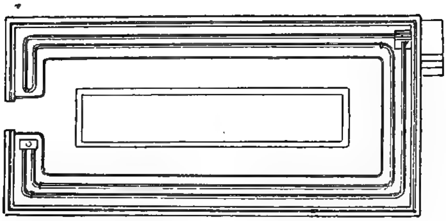




Gable.

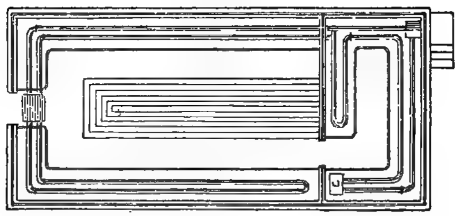
HOLLAND HOTHOUSE.





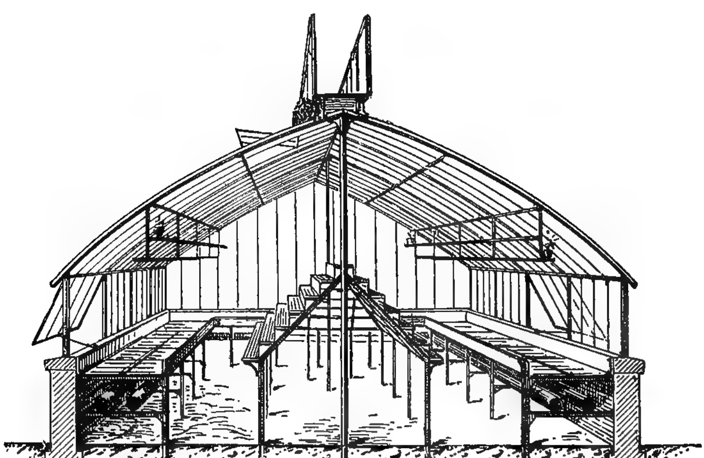
Temperate.

40 ft. by 16½ ft.; costs, complete, $900.



With hot-air chamber.

40 ft. by 16½ ft.; costs, complete, $1,000.



Transverse section.

HOLLAND HOTHOUSE.

being the curved roof. The construction and internal arrangement can be easily understood by the illustrations (Figs. 11 and 12, Pls. VI, VII).

In addition to these two forms of construction, were a number of examples of the conservatory or winter garden, intended for the

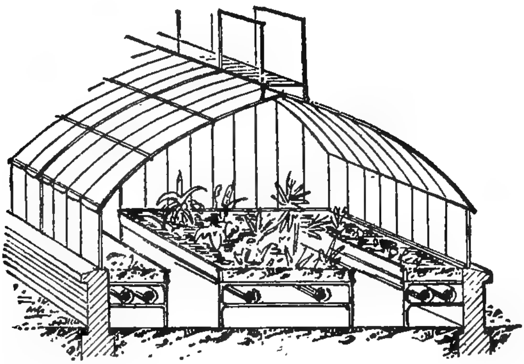


FIG. 12.

display of plants, rather than for their propagation (Figs. 13 to 15).

The lines here, too, were pretty much the same, with variations in the proportions and the minor details. Almost all consisted of a central dome-shaped structure, serving as a palm house, with two wings of less altitude.

These, with the hothouses having but one sloping side, constructed against a wall, constitute all the principal varieties employed. (Fig.

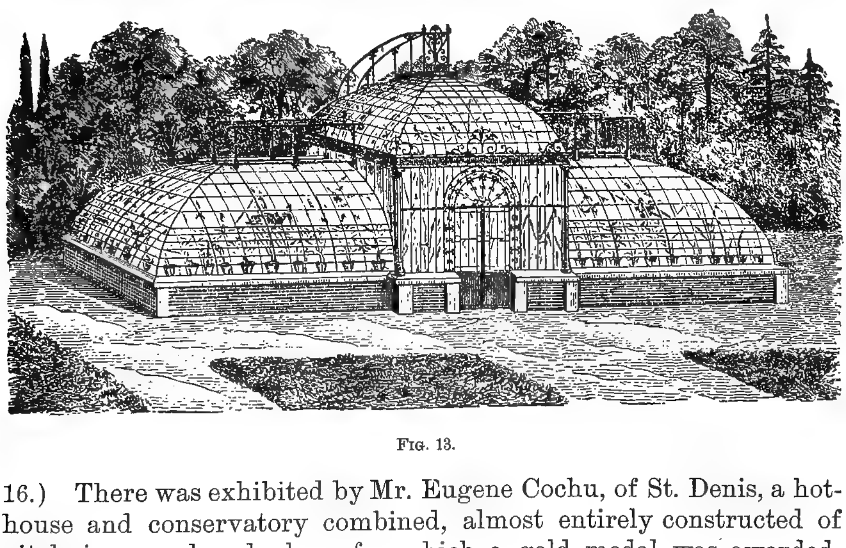


FIG. 13.

16.) There was exhibited by Mr. Eugene Cochu, of St. Denis, a hothouse and conservatory combined, almost entirely constructed of pitchpine wood and glass, for which a gold medal was awarded. (Fig. 17.)

The novelty consisted not merely in the use of pitch pine instead

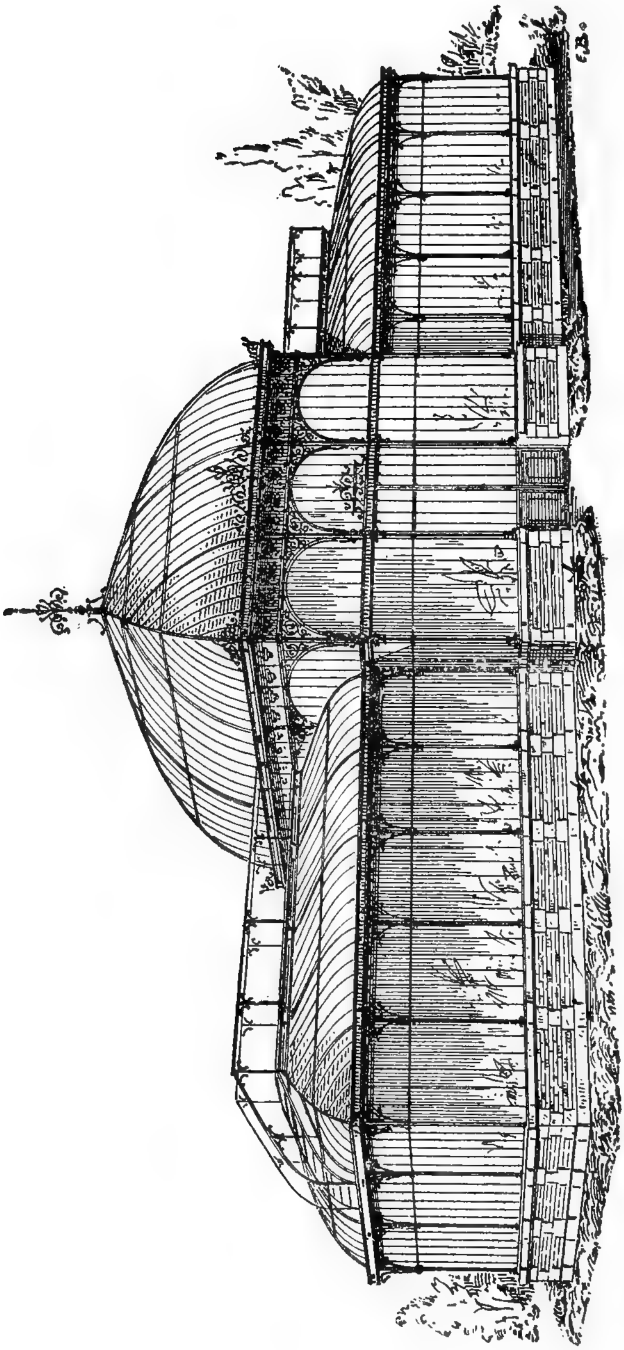


FIG. 14.

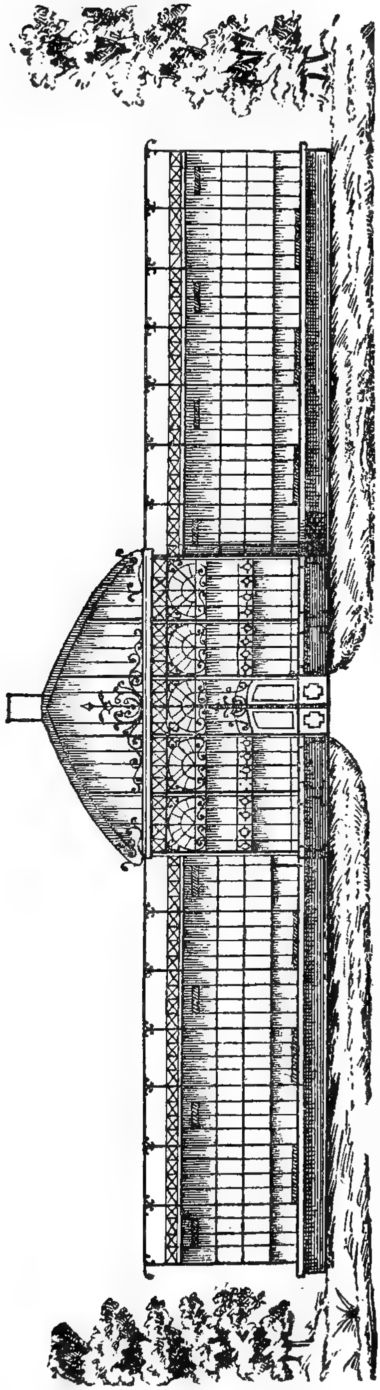


Fig. 15.

of iron in the construction, but more properly in the use of a double glazed roof frame, with a space of $1\frac{1}{2}$ inches between the glazing; small slabs of wood, moving on a central pivot at the inferior openings, made it easy to control the movement of air between the two glasses, and prevented or accelerated the absorption or radiation of heat, thus avoiding to a great extent the use of a mat covering; the

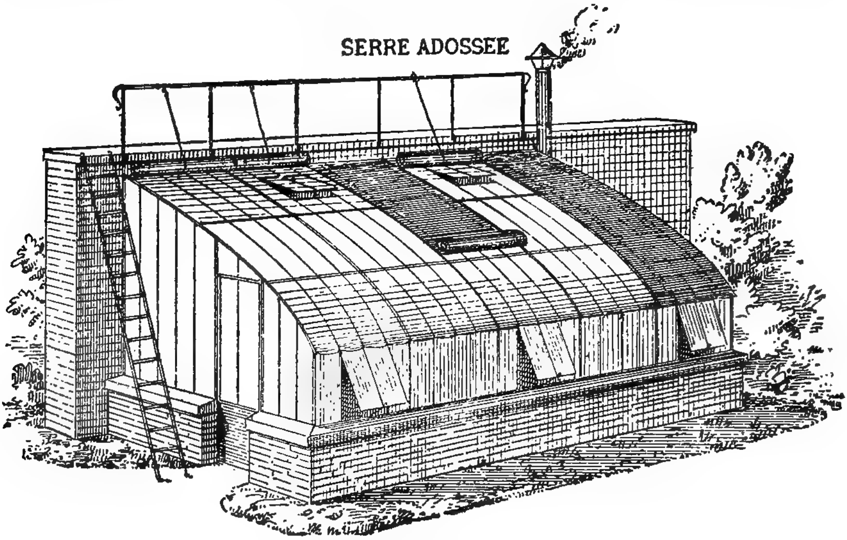


FIG. 16.

wood, as compared with iron, being more of a nonconductor, had that further advantage.

In many of these buildings were very interesting special exhibitions of orchids and other rare plants.

Figs. 18 and 19 show two designs for window gardens in iron work.

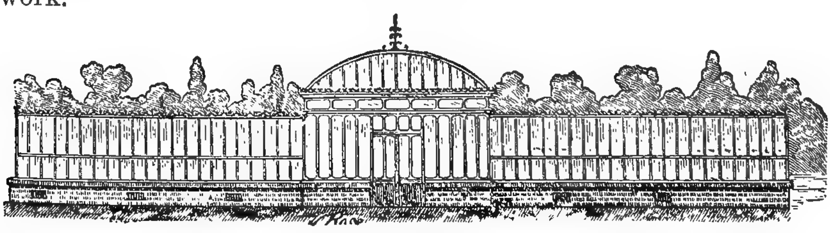


FIG. 17.

AGRICULTURAL AND HORTICULTURAL IMPLEMENTS.

Very little that was new was exhibited in the way of horticultural implements.

In another part of the report is given a full description of the tools used by the Forestry Department, for sowing, and for replanting trees.

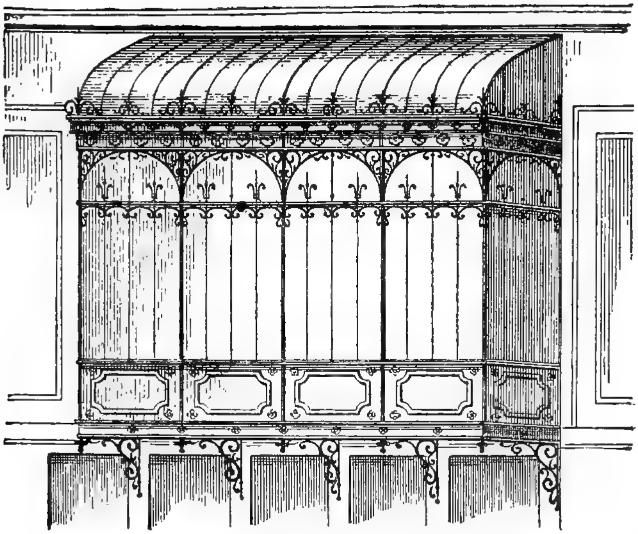


Fig. 18.

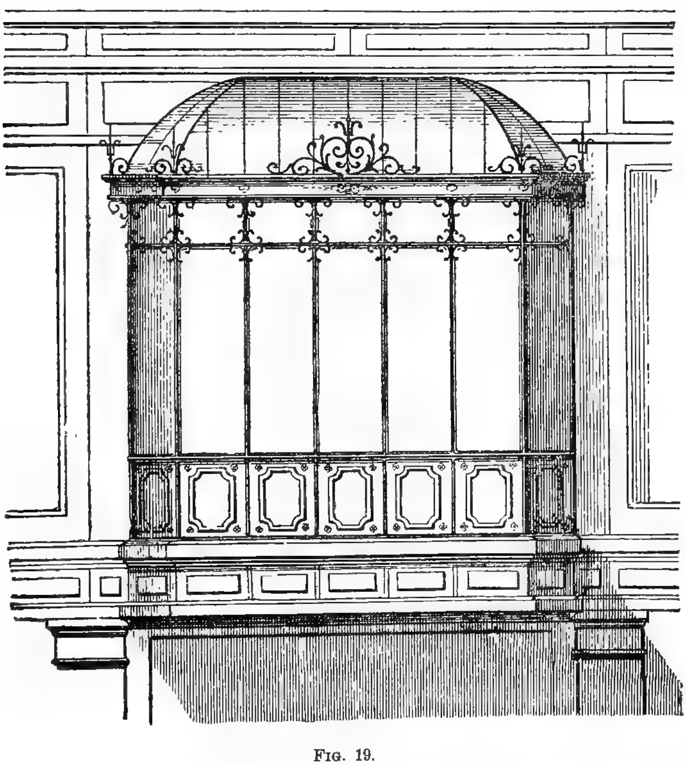


Fig. 19.

The accompanying illustration (Fig. 20) shows an improved weeder and rake for garden walks. The knife in front cuts the weeds out of the ground. The weeds are then collected by the rake behind, which can be freed of the same by the action of a lever placed between the handles. This knife can be adjusted so as to penetrate more or less as may be wished. The model represented is intended to be drawn by a pony. There were others smaller, for hand power.

An apparatus called an "insecticide" (Fig. 21) that seemed very efficient for sprinkling plants with any liquid preparation, against insects or disease, constructed on the same principle as the well-known perfume sprinkler, was on exhibition by M. Loriot.

Tubs or boxes of all kinds for large plants, made of iron, wood, or both combined, and of both plain and a highly ornamented character, were shown. Among them were those constructed according to the system of Mr. Ribet, and which opening in every direction, offered great advantages for the care of plants, permitting repotting without disturbing the roots, also the removal of diseased parts of the latter, and changing the earth. (See illustration Fig. 22.) The most expensive and largest are $20 and the smallest $5.

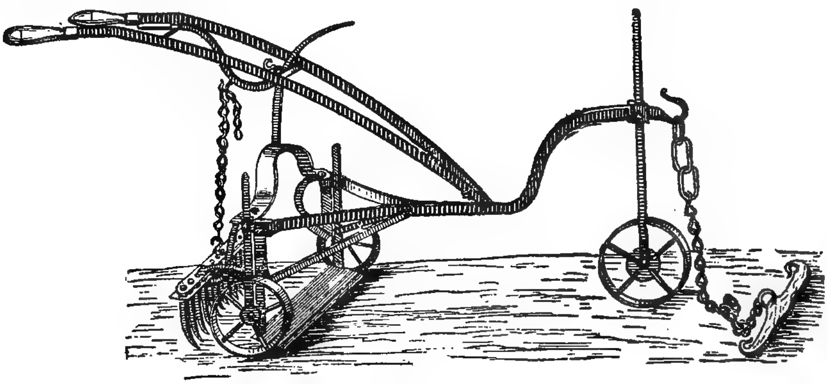


FIG. 20.

Another style were in oak and galvanized iron. (See Fig. 23.)

ARRANGEMENT OF FARM AND KITCHEN GARDEN.

The question is often difficult to solve as to where the farm commences and the garden ends. There is, however, an intermediate stage as regards the vegetable garden, which serves to make the transition more easy to define. What is called here a market garden (in French "la culture Maraichère") corresponds to what is known in America as a truck farm—that is to say, the cultivation of vegetables for market on a large scale. The ordinary vegetable garden attached to a private house—the kitchen garden—is in French the "jardin potager." In the latter case the garden is divided off into

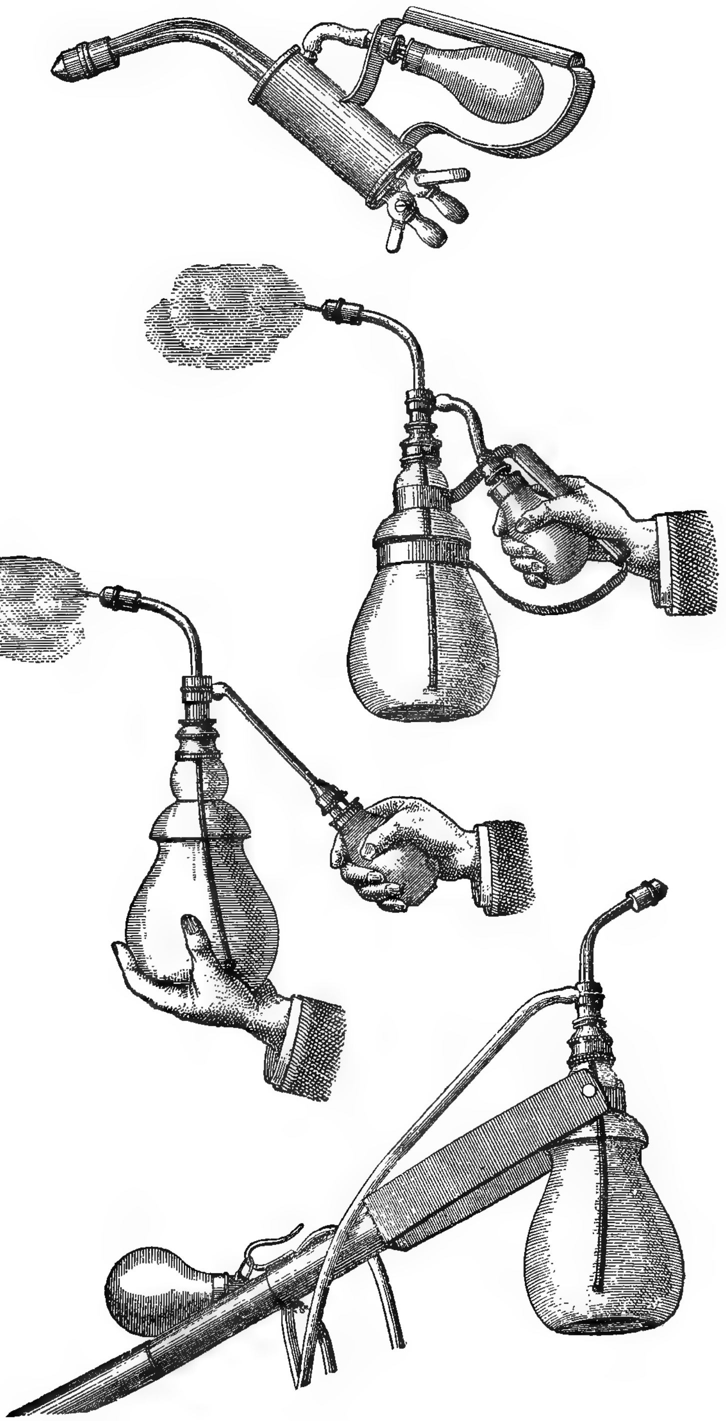


FIG. 21.

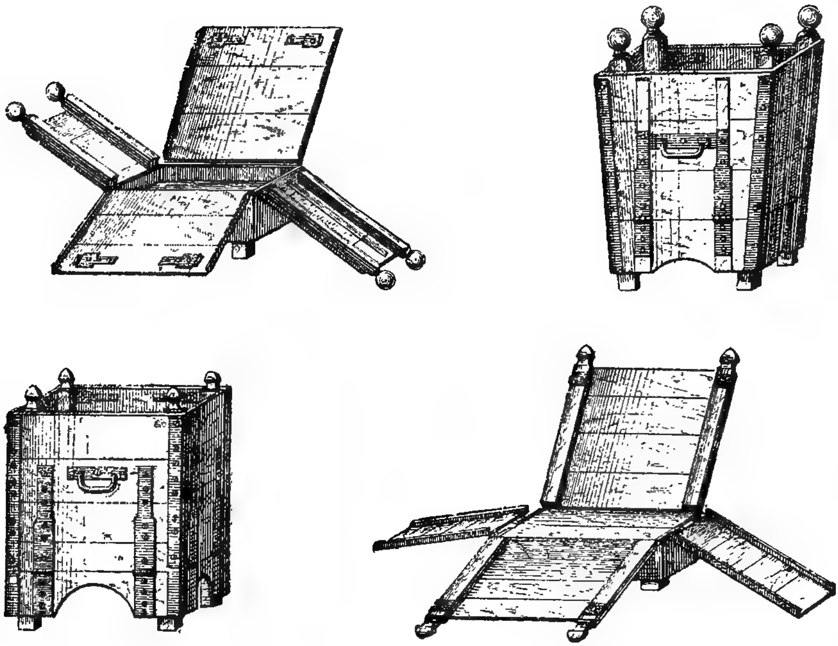


FIG. 22.

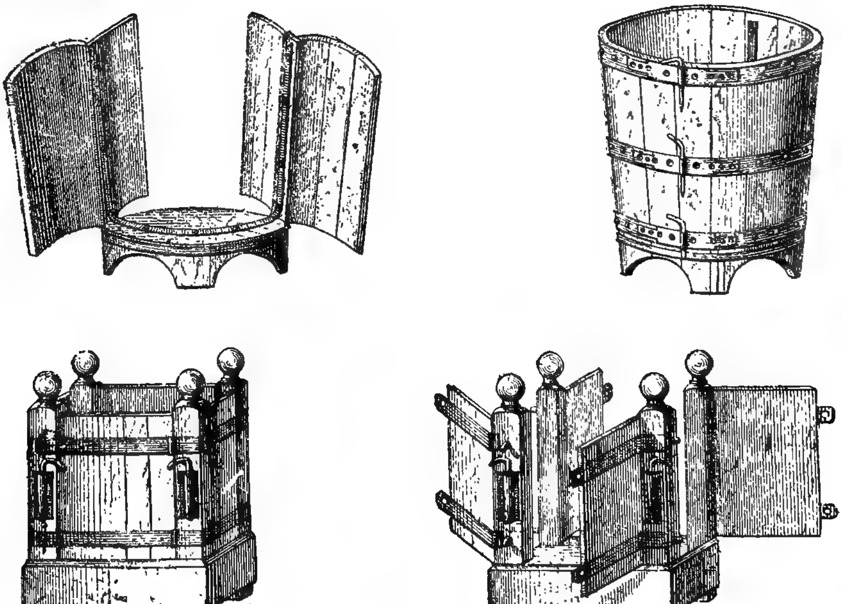


FIG. 23.

plots, having a small passageway of a foot wide between them, for watering and other care of the plants ; the plots are generally about 9 feet by 4. In these are planted all the current varieties of vegetables and salads required.

The accompanying plan (Fig. 24), with the explanation given below, will not only assist in forming an idea of the usual French kitchen garden as to its disposition, but will permit at the same time the designation of its contents and their position.

This garden is supposed to form a parallelogram, containing about an acre and a third ; space sufficient to secure the rotation of plantation.

It is recommended that the garden be inclosed by a wall on the north, east, and west, by which a south, east, and west exposure is secured. The southern end can, if necessary, be closed by a hedge. The wall ought to be at least six feet high, and, if in solid stone, should be covered interiorly with a light trellis work and the top capped with tiles or slate, projecting some nine inches, in order to protect wall fruit from the rain, and further, by suspending coarse cloths, early peaches, etc., can thus be protected from the spring frosts.

On the east side, grape vines should be planted, on the west, peaches, and in the intervals wall pear trees, which latter can be planted as well on the northern wall, choosing varieties which ripen quickly. Late plums and cherries can also be planted here.

In some obscure, out-of-the-way corner of the garden, a pit should be dug, to receive all the refuse, which in time turns into valuable manure.

A proper supply of water is of course a vital question. This should pass by pipes laid in the paths, so that any necessary repairs can be made without disturbing the plants. This supply is concentrated in one or several tanks, either in the central spot 62 or in barrels sunk in the ground at the extremities of the beds, between 8 and 9, 24 and 25, 34 and 35, 50 and 51. (See plan.) This is of the first importance, as a convenient supply of water is essential, not only during a season of drought, but also at the moment of planting the seed, and the time of its germination.

The central path should be about 9 feet wide ; those making the circuit and crossing, should be about 6 feet, and the passages between the beds, as mentioned above, need not be more than a foot in width, just sufficient to pass with the watering pot, or stand for weeding. The first row of plants ought to be 4 inches from the border.

The beds (61) in the middle pathway, and those of the side or crossing paths, should be 5 feet wide and bordered with box. Here pear trees in form of pyramids should be planted, about 25 feet apart, with dwarf apple trees between each.

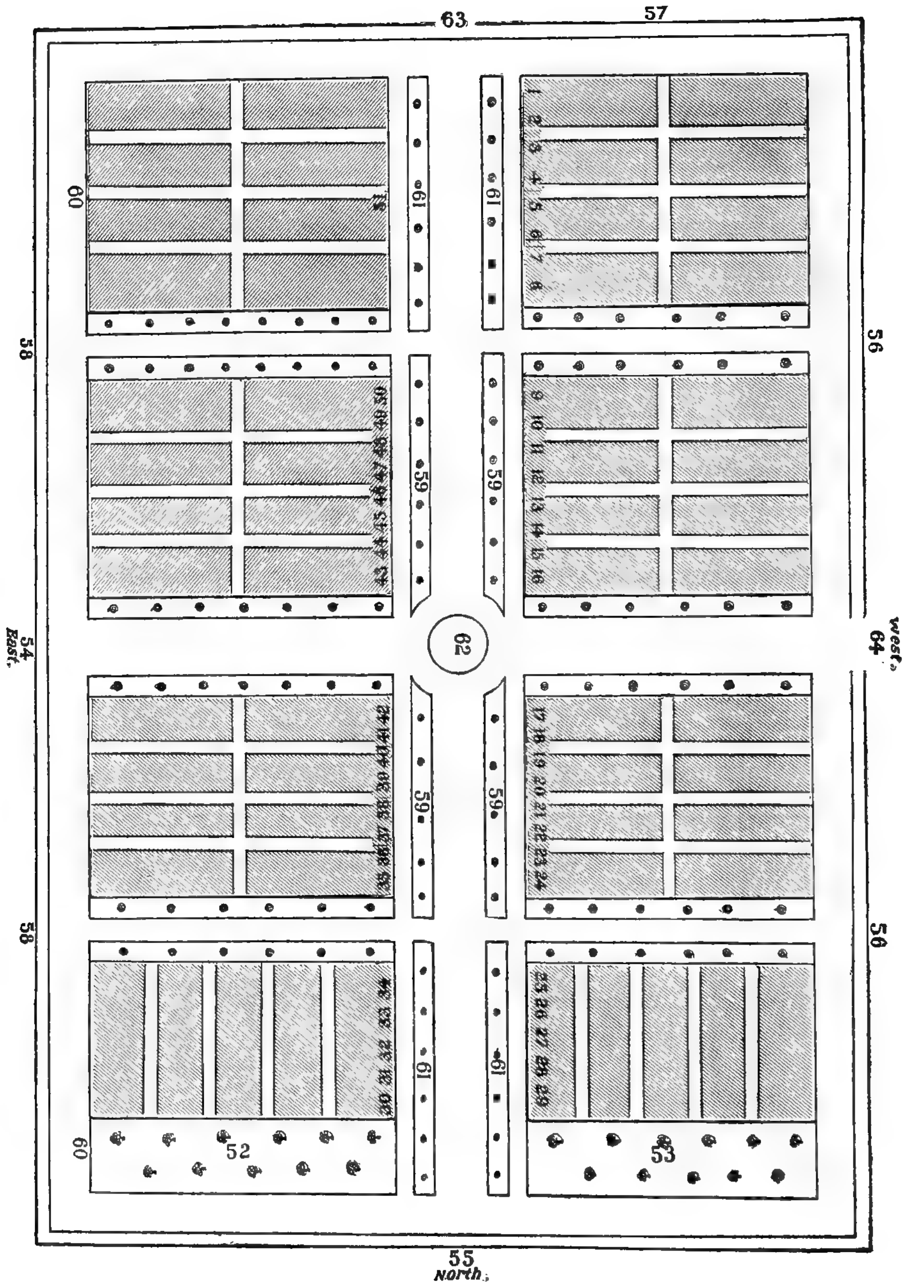
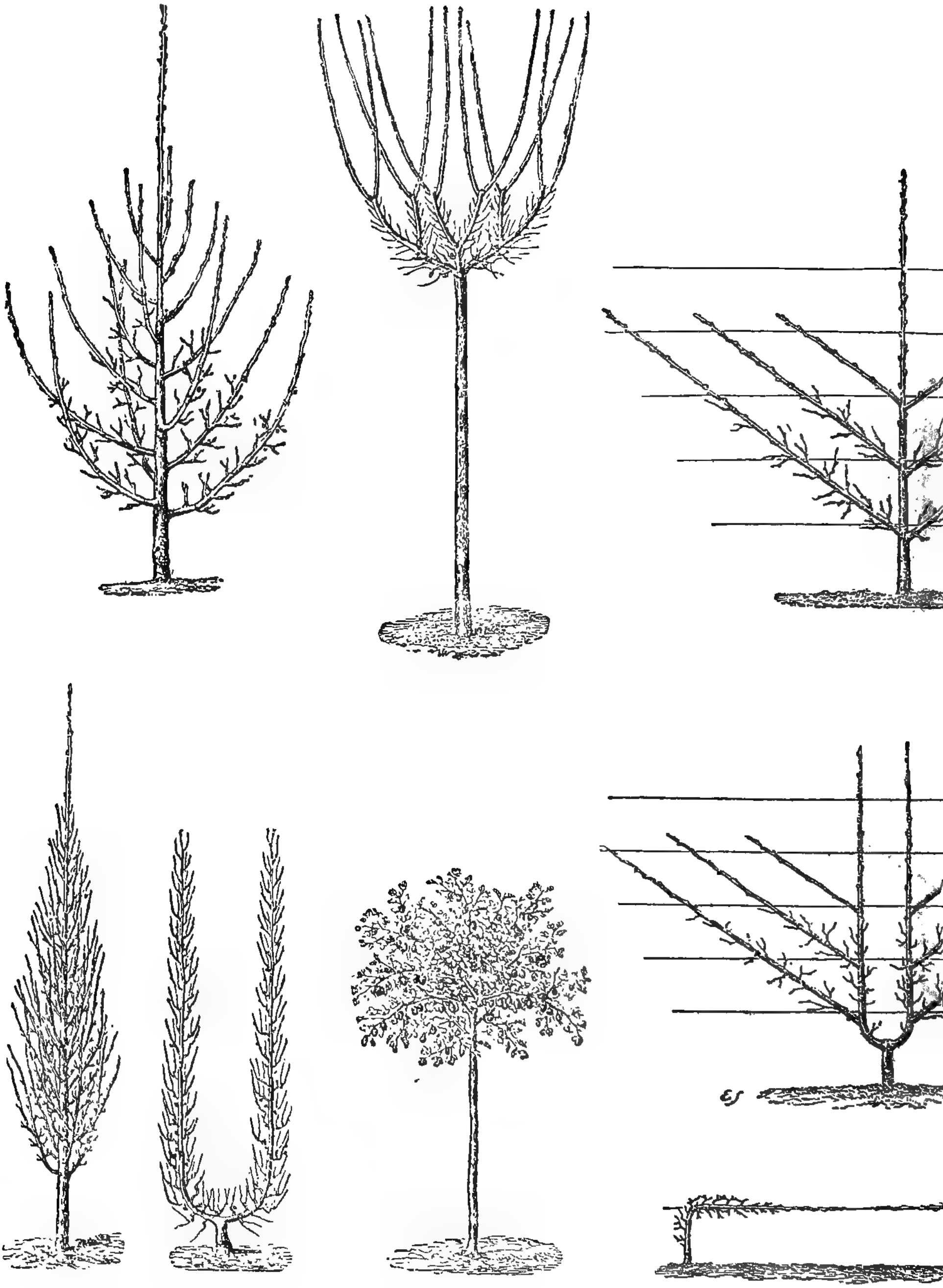
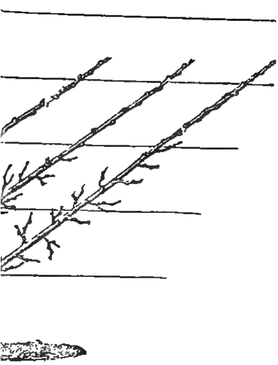
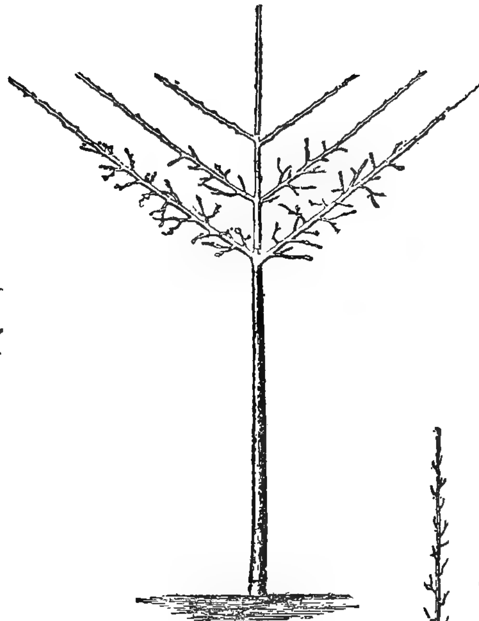


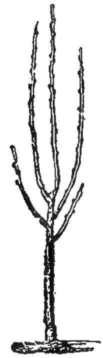
FIG. 24—Plan of a kitchen garden.

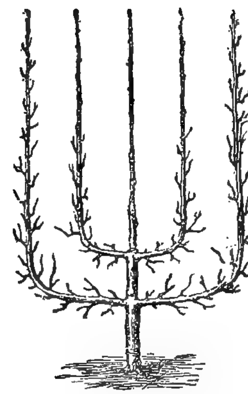


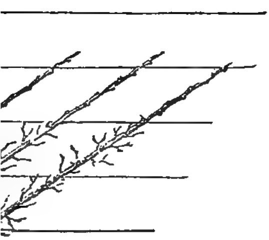
TREES CUT











SPALIER.

FRENCH FORESTR

Y BUILDING.

FRENCH FORESTRY BUILDING.

The square containing Nos. 1–8, is used for sowing seed and for preliminary plantations for the kitchen and ornamental garden.

Nos. 9–29, and 30–50 are beds to be used for planting.
No. 51, the hot beds.
No. 52, currants and gooseberries.
No. 53, raspberries.
No. 54, side bed about 9 feet broad for vegetables.
No. 55, band about 6 feet wide (good position for English rhubarb).
Nos. 56 and 57, same as above.
No. 58, grapevines.
No. 59, band about 3 feet wide.
No. 60, row of grapevines, supported on stakes placed at the end of each bed, in a way so as not to interfere with the passage.
No. 61, band about 5½ feet.
No. 62, tank.
No. 63, door for Gardener.
No. 64, communication with the pleasure garden.

The accompanying illustrations Trees cut Espalier (Plate VIII) will show in what condition fruit trees are generally delivered from a French nursery; having received the preliminary direction of growth, the preservation and continuation afterwards, depends upon the skill of the gardener to whom they are intrusted.

FORESTRY BUILDING.

Implements, Views of Operations, Bibliography,

The forestry pavilion, of which the accompanying illustrations (Plates IX and X, and Fig. 25) give capital views, was a model of artistic and intelligent design. It was constructed entirely of wood covered with its natural bark. Trunks of different species of trees served as columns to support a spacious portico, which surrounded the three principal sides of the ground floor; corresponding trunks were inserted in the form of pilasters in their proper place against the wall of the building proper. The capitals were formed by an arrangement of interlaced twigs, and the plinth and torse were represented in an equally rustic manner, the latter ornament being formed by thick rope from the bark of the Linden. All these trees were labeled with both their botanical and their popular names. The same system was pursued in the interior of the building, which consisted of an imposing court, covered with a canvass roof, separated into larger panels by light beams. The upper floor, formed by the projection over the portico without, was a graceful gallery which surrounded this court on all its sides, access being obtained by a double stairway, appropriately decorated in the same style as the rest of the building, with ornaments of an architectural character, in wood, almost invariably in its natural state.

The ground floor formed one unbroken space. The center was

occupied by an exhibition of machines used for sawing logs, transporting lumber, etc. Also a very interesting collection of different kinds of wood, in the shape of cross-sections of the trunks of trees which, after having been cut, so as to indicate the most advantageous way of utilizing each species, were retained in their original form by iron bands. In most cases not an inch was sacrificed, except in the path of the saw.

The wall space around was divided by projecting tree trunks, into shallow alcoves supporting the architrave of the gallery above, in which were arranged specimens of different woods in their rough state; these were surmounted by a sort of panoply of the various

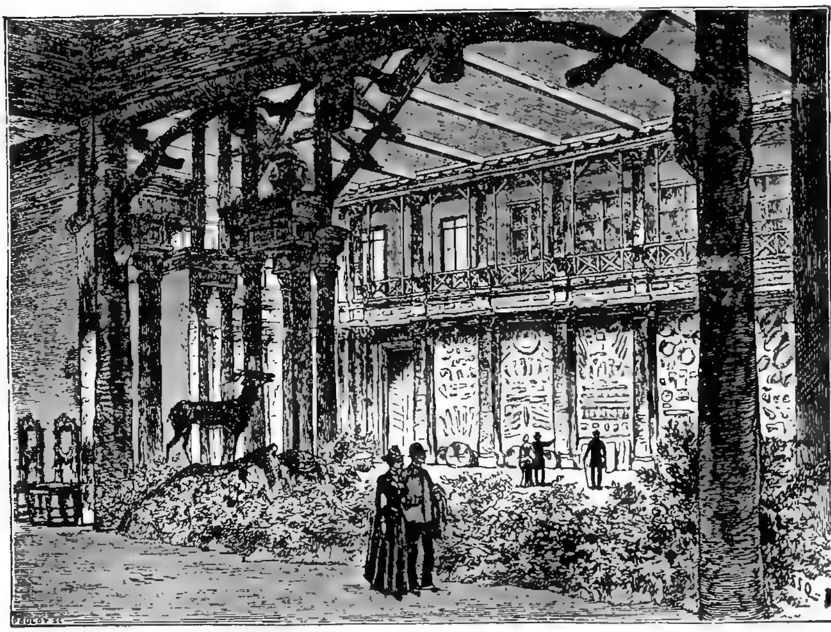


FIG. 25.—Interior of Forestry Building.

instruments and utensils that could be manufactured from each species. The effect produced was really striking, especially when the insignificant nature of the objects was considered, and was truly an admirable example of French taste and ingenuity in arrangement.

In the gallery above was a similar exhibition of woods, but it was more especially devoted to the scientific questions of forestry. One section contained a collection of Herboriums, contributed by the Government and the forestry schools; also specimens of different sorts of wood, with the fungi which especially attacked them, and numerous small cases, showing the different insects which preyed upon

their leaves and trunks. There were, as well, specimens of all the various tree seeds and the cones of the evergreens. Practical illustrations of the results obtained by the use of the microscope in sylvan botany, were shown in an interesting and popular form.

In a building which formed a projection on one of the sides of the lower floor, were three very well executed dioramas, showing the operation of rewooding districts in the Alps, and the accompanying work, to force the mountain torrent into something like its original bed. Regarding this, full details are given further on. The Forestry building covered a space about 145 feet long by 100 broad, had a height of 55 feet, and some 39,500 cubic feet of wood were employed in its construction.

The flat ornamentation of the exterior walls was effected by a combination of strips of bark from various trees, among which, birch was most conspicuous and was highly effective, relieving the building from any appearance of heaviness or monotony.

The trees forming the columns of the porticos, represented a good portion of the extremely limited number of French indigenous forest trees. There were examples of the following varieties :

Variety.	Age.	Girth.	Variety.	Age.	Girth.
	Years.	*Inches.*		*Years*	*Inches.*
Quercus penunculata (Ehrp.)......	150	57	Pinus laricio (Toir.)......	60	52
Quercus sessiliflora (Smith)	150	57	Carpinus betulus (Lin.)...........	100	50
Quercus robur................	150	58	Fraxinus excelsior (Lin.).........	80	50
Ulmus campestris (Smith)	120	58	Pinus pinastes (Soland.)..........	50	54
Fagus sylvatica (Lin.)...	160	60	Sorbus domesticus (Lin.).........	200	58
Pinus sylvestris	60	50	Cerasus avium (Bröck.)...........	90	54
Abies pectinata (Candolle)	120	60	Aluns glutinosa (Lin.).............	70	54
Populus canescens (Smith)........	45	60	Populus nigra (Lin.)	50	58
Robina p. acacia (Lin.)............	50	60	Picea excelsa (Lam.)	100	54
Castanea vesca (Lam.)............	80	54	Larix Europea (Candolle)........	70	52
Betula verrucora (Ehrh.)..........	90	54			

Among these trees there were a number of specimens of each variety, but the oaks predominated and in fact formed about one-half of the whole. As will be seen in the plate they were chosen more with reference to similar girth than age, in order to obtain uniformity of effect.

Between the columns of the portico was a graceful and rustic balustrade.

The two entrances at each end of the façade, were approached by flights of steps of similar style, and were made a feature in the design, corresponding with the more elaborate portions of the decorations, and on the roof line they were surmounted by two gable ends.

The ground floor, before described, was divided into alcoves, in which were displayed some of the various objects which could be

manufactured from the several woods to which each was devoted. The following are some examples :

Larch.—Buckets, firkins, measures.

Yew.—Principally wheel hubs, and a variety of carved articles.

Alder.—Legs of chairs and tables, turned and slightly carved, guitar handles, spigots, fine wooden shoes, etc.

Chestnut.—Fine flooring (parquet), churns, measures, baskets.

Beech.—Wooden shovels for grain, measures, handles of saws, yokes for oxen, pack saddles ; brush backs.

Oak.—A great variety of examples of its utility for every imaginable purpose.

Ash.—(*Fraxinus excelsior*): Carriage wheels ; of other species, spigots, wooden dishes, sabots.

Walnut.—Various articles of furniture, gunstocks, etc.

Pear wood (*Pirus communis*).—A number of small articles, delicately carved and turned.

Wild cherry (*Cerasus avium*).—Used largely for making articles in imitation of bamboo, hat racks, etc. ; also pipes, small turned objects of a variety of kinds, rulers, etc.

Maple.—(*Acer campestris* Lin): Molds, spade handles, scythe handles, saddles, squares. *Acer mons pessulanum :* Spigots and turned cases for bottles. *Acer p. platanum :* Bottle boxes, violin handles, brush backs, fans, and inlaid work.

Lime or Linden (*Tilia platyphyllos* Scop).—A number of specimens of strong rope made from its fibers.

Fir (*Abies pectinata* Candolle).—There was a section of the base of a trunk shown 175 years old and nearly 6 feet in diameter. The objects were boxes and tubs and small carved animals and toys for children.

Spruce (*Picea excelsa*).—A section 180 years old was 3 feet in diameter. Coarse tubs, thin bent-wood boxes, pill boxes, fine shavings for packing, bodies of violins.

Pine (*Pinus maritima*).—Specimen 400 years old ; diameter 6 feet (but near the base) ; suitable for coarse work and burning ; barrels, broom handles, and stakes.

Birch.—Wooden shoes, barrels, yokes, table legs, fine wooden shoes for women.

Poplar.—Boxes, clock case, case for violoncello.

Quivering poplar.—Wooden match boxes, and light boxes of all kinds.

The forest trees of France consist of a comparatively small number of varieties which are indigenous, and but few species which have been naturalized. Those that are found in great quantities together, are not more than eighteen in number, which are native to the soil. They are the following :

Quercus robur Lin.,* *Quercus Pedonculata* Ehrh., *Quercus sessiliflora* Smith,* *Fagus silvestris* Lin., *Castanea vulgaris*, Lamarck, *Quercus tozza*, *Quercus tuber*, *Quercus occidentalis*, *Quercus ilex*, *Carpinus betulus* Lin. (called sometimes False Birch), *Abies pectinata* De Candolle, *Picea excelsa* Lam., *Larix europæa* De Candolle, *Pinus silvestris* Lin., *Pinus laricio* Poiret, *Pinus maritima* Soland, (or "Pinaster"), *Pinus halepensis*, *Pinus chembro*, and *Pinus montana*.

The subordinate varieties, which are found either isolated or growing together in small clumps, consist of some 49 specimens, all except two, of a deciduous character. Of these, 14 are of large di-

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* Essentially the same tree.

mensions: Two species of Lime trees, 2 species of Maples, 1 species of Ash, 2 species of Elms, 1 species of Willow (*Salix alba* Lin.), 3 species of Poplar, 1 species of Pine (Pinus pinea),† 12 are of medium size, all deciduous, *Acer campestre, Cerasus avium, Sorbus domesticus, Sorbus torminalis,* 2 species of Birches, 2 species of Alders, the Quaking Aspen, etc.

The smaller varieties are 22 in number, of which one, the common Ilex, is resinous. The rest consist of the olive tree, the common pear tree, the crab-apple tree, etc.

These various specimens of trees are found in the different sections of the country, which are especially adapted by soil and climate to their several characters. The larger portions of France having a temperate climate, trees which flourish best under such conditions form naturally the majority. The whole country may be divided into three regions, according as the climate is warm, temperate, or cold.

The first consists of the Southern Department, on or near the Mediterranean; here are found in great abundance the Quercus ilex, suited to the calcareous formation of those regions; the Pinus halepensis; Quercus suber; and, in the higher regions, Pinus cembro. This, too, is the home of the olive tree. On the Atlantic side, where the soil is mainly sandy, are found vast forests of Pinus maritima.

Where a moderate climate prevails, oaks and false birch (*Carpinus Betulus*) are found in great abundance, with but few native resinous trees, excepting perhaps the Pinus Silvestris.

In the cold mountainous regions in the lower valleys, are found large numbers of beeches, firs, and the Pinus Silvestris, and on ascending higher, the spruce is the principal tree, and higher still are larches, with a few spruces, and the Pinus Combro.

The table herewith will show the distribution of the principal varieties of these trees, which are under the supervision of the Forestry Department.

Species classed according to their superficial importance.	Extent of ground covered by each species. Absolute.	Relative.	Species classed according to their superficial importance.	Extent of ground covered by each species. Absolute.	Relative.
	Acres.	*Per ct.*		*Acres.*	*Per ct.*
Quercus robur and pendonculata	1,885,360	29	Quercus ilex or alex	273,385	[illegible]
Fagus silvestris	1,235,900	19	Pinus maritima	233,280	3.1
Carpinus betulus	742,790	12	Picea excelsa	188,365	2.9
Abies pectinata	480,300	7	Larix europæa	107,070	2
Pinus silvestris	295,980	4.5	Sundries	1,007,550	[illegible]
				6,479,920	100

†Same as the stone Pine of Italy.

To complement the above, a table giving the distribution of the various species by quantities will be found interesting.

(Trees only are cited.)

Trees classed according to their nature.	Principal varieties.				Secondary varieties.				
	First importance	Second importance.	Third importance.	Total importance.	First importance.	Second importance.	Third importance.	Total subordinate.	Total.
	1	2	3	4	5	6	7	8	9
Indigenous sorts:									
Deciduous	4	4	1	9	13	12	21	46	55
Resinous	7	2	....	9	1	....	1	2	11
Total*	11	6	1	18	14	12	22	48	66
Naturalized species the most frequently cultivated †	2	....	...	2	6	3	10	19	21
Species suited to hot climates ‡	1	3	1	5	1	3	8	12	17
Species suited to temperate climate capable of living in the two others	5	2	...	7	13	8	8	29	36
Species suited to cold climate	5	1	....	6	...	1	6	7	12

* *Indigenous varieties.*—Column 1. Beech, chestnut, oak (robur and pendunculata), fir, spruce, larch, *Pinus silvestris*, *Pinus larico*, *Pinus maritima*, *Pinus chembro*. Column 2. *Quercus Tozza*, *Suber*, *Occidentalis*, *Carpinus betulus*, mountain pine, and alpine pine. Column 3. *Quercus ilex*. Column 5. *Lilia platyphyllos*, and *silvestris*, *Acer plantanoides*, *Acer pseudoplatanus*, *Fraxinus excelsior*, *Ulmus campestris*, *U. Montana*, and *U. effusa*, *Quercus cerris*, *Salix alba*, *Populus alba*, *nigra*, and *canescens*, *Pinus pinaster*. Column 6. *Acer campestris*, *Cerasus avium*, *Torbus domesticus* and *torminalis*, *Fraxinus oxyphyllis*, *Celtis australis*, *Quercus fontanessi*, *Betula pubescens*, *Betula alba*, *Alnus glutinosa*, *Populus tremulus*, *Alnus cordiforma*. Column 7. *Negundo Frakini folium*, *Acer mons pessulanum*, *Melia azerderaca*, *Pistache* tree, *Caroubier*, common pear tree, crab-apple, *Torbus orminalis* Crantz, *T. latifolia*, *T. toria*, Crantz, *S. aucuparia*, olive tree. *Aluns alba*, *Alnus pubescens*, *Salix fragilis*, *S. Caprea*, and others, *Taxus buccata*.

† *Naturalized varieties.*—Column 1. *Pinus strobus* Weymouth. Column 5. Horse chestnut, walnut, eastern and western plane trees, Canadian poplar, cypress. Column 6. False acacia, black and white mulberry. Column 7. Jujube, pistache, and almond trees, *Prunus avium*, *Prunus domestica*, quince tree, weeping willow, etc.

‡ *Species peculiar to warm regions.*—Column 1. *Pinus maritimas*. Column 2. *Quercus tuber* (Mediterranean), *Quercus occidentalis* (Atlantic), *Alpine pine*. Column 3. *Quercus ilex*. Column 5. *Pinus pinea* of Providence. Column 6. *Fraxinus oxyphyllis*, *Celtis australis*, *Quercus fontanessi*. Column 7. Olive tree, Montpellier maple, and several others.

In the report of the French Forestry Department, from which these indications are drawn, further details are given regarding the nature of the soil suited to each species, the most favorable situations for planting, and complete details as to the duration of the fecundity of the seeds of each variety, and the best means of preserving their force.

The following general principles are put forward as to the restoration of waste places in a forest, being the results of experience in France.

In the first place the nature of the soil and climate must be carefully studied; varieties of a native growth should be preferred to those of an exotic origin, for the acclimatization of a forest tree is a myth, and even its naturalization is often extremely doubtful.

Where these waste places have existed for a long time, the soil, under the influence of light, heat, and dampness, has in a great measure lost its fertility ; this more especially on sloping ground, and in a forest of oaks or beeches, it would be impossible to fill these spaces successfully with anything, except trees of a resinous character.

It is recommended that plantations be formed of different species together, a condition being that the growth should approximate, whilst the roots of one tree shall have a tendency to push deeper than the other, as, for instance, an oak with a beech; a beech and an ash ; a beech with a maple ; a fir and a beech ; fir and spruce, etc. Besides this, it is well to have a hardy variety to protect the growth of a more tender, and often when the first has served its purpose, it represents a profit sufficient to pay the whole outlay.

The advantages from a financial point of view, by the various operations attending the restoration of a forest, are easily proved in France, where labor is cheap and experienced, a market within easy reach, and all the elements of success near at hand. The statistical result so obtained, would not be of much use to anyone studying the question in the United States, unless developed in all its details.

Our own forestry exhibit was extremely interesting, but lacked space for its proper display, and, being at the entrance of the section where it was placed, was not in a convenient situation for quiet inspection.

In all of the South American special exhibits, their wood products were a feature, and were well arranged for study and comparison.

DESCRIPTION OF TOOLS, ETC.

The implements used to plant forest trees (Figs. 26–53), have been much improved of late years by Mr. Prouvé, inspector of forests, who starts from the well-known general principle, that in transplanting the main object should be to remove the tree with the roots and their fibrils, in as unmutilated a condition as possible.

For this purpose he makes use of a spade having the qualities of a lever (Fig. 52), which has various dimensions, viz, from 2 feet to 20 inches for the iron end, which is 5½ inches in width at its broadest part; the handle is also of iron (Figs. 43, 46, and 53 show the method of using this tool). It is recommended that two should be used together ; in this way it is easy to unroot the tree in one lump, when, after cleaning the dirt away from the roots, the re-planting is effected by making the necessary cavity by means of the same lever spade, and pounding the earth well into the roots, as represented in Figs. 45, 48 and 50.

Mr. Prouvé recommends that the stem of trees so planted should be inclined in the direction of the sun at noon in spring time, and for

this reason; the bark of young trees is very sensitive to the action of the direct rays of the sun, and is capable of resistance only, when the movement of the sap is sufficiently active to keep the bark fresh. If, however, the circulation of sap is slow or suspended after the transplantation, the bark becomes dry and brown, and the tree ultimately dies. He states that in the case of numbers of beech trees planted at the same time, those that stood erect or leaned toward the north, were in a great measure lost, whilst those inclined to the south, having their stem in the axis of the sun's rays at the hottest moment of the day, were uninjured and remained green. (Fig. 50, shows a young tree so planted.)


FIG. 26.

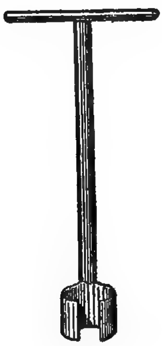


FIG. 27.


FIG. 28.


FIG. 29.

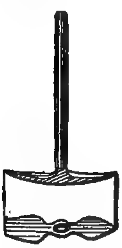


FIG. 30.


FIG. 31.

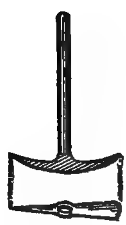


FIG. 32.


FIG. 33.

DESCRIPTION OF THE TOOLS USED FOR FRENCH FORESTRY PLANTING.

FIG. 26.—*A planting mace.*—This is used in the case of soils of light consistency. The hub-shaped extremity is about 13 inches high by about 7 inches broad, rendered solid by iron bands top and bottom. Underneath is an opening in which may be adjusted a small iron cylinder, varying from 1½ inches to 2½ inches long by 1 inch to 2 inches in width. By a vertical blow, this projection makes a small hole in the ground, and in this the seed is placed, the moist-

ure around is retained, whilst the compressed earth preserves the cavity and thus affords a protecting wall to the young plant.

FIG. 27.—*Circular spade.*—This has been in use for several years with very successful results for planting resinous trees. The iron has the form of a half section of a truncated cone—the upper and broader part being 4¾ inches wide and the cutting end 4 inches. The length is 10 inches. The handle is about 34 inches. By a simple movement, a truncated cone of earth is cut out having the same dimensions, which is placed alongside of the hole thus made. The young plants are placed by a woman or a child, whilst another workman following, sprinkles over the roots the friable portion of the earth extracted, and replaces the caked surface in the position it occupied before, pressing it with the foot. In this way the young roots are effectually protected from the air.

FIG. 28.—A spade of the same character as No. 2.

FIG. 29.—*Planter with flanges.*—Four concentric projections perpendicular to each other and ending in a point. The iron is 6 inches long, with a diameter in the middle of about 2½ to 1¼ inches, according to the size of the seed to be planted. This is used for stiff, clayey soil. The instrument is driven into the ground and turned backward and forward until the hole is partly filled with loose earth into which the seed—an acorn for instance—is dropped.

FIGS. 30 and 31.—Require no special explanation.

FIG. 32 is a pick used when the slope is too considerable to use a plow to open a trench.

FIG. 33.—This is a species of ax, and is used to cut a wedge out of soil which is replaced over the planted seed.

FIG. 34.—A hoe used to remove the sod previous to planting, as shown in No. 37.

FIGS. 35 and 36 explain themselves.

FIG. 39 works as an auger in making the hole for planting.

FIG. 41.—Seed sower, invented by Mr. Prouvé; consists of a tin tube cut obliquely, funnel-shaped at its upper extremity and terminating with a lance head pointed with steel; with this a slip of earth is raised, holding the implement in one hand, whilst with the other the seed is dropped into the funnel, and passing through the tube finds its proper position. The earth is then pressed down with the foot.

FIG. 42.—Similar instrument for small seeds.

FIGS. 43 to 50 described elsewhere.

FIG. 51.—This planter consists of a solid cylinder slightly flattened and terminating in a point; there is an iron projection at the point of junction with the handle, against which the foot is braced when forcing the planter into the ground. The length of the cylinder varies from 20 to 24 inches. This is used in connection with the two implements shown with it, which consist of hollow tubes made

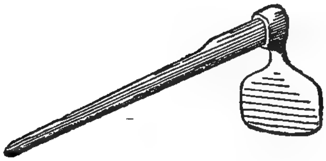


FIG. 34.


FIG. 35.


FIG. 36.


FIG. 37.


FIG. 38.

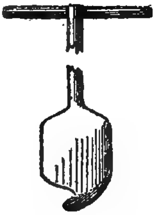


FIG. 39.


FIG. 40.

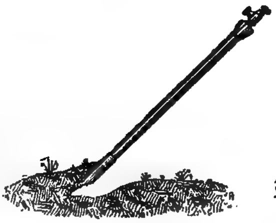


FIG. 41.

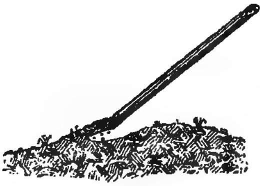


FIG. 42.

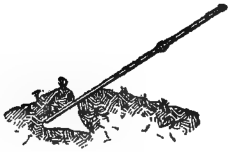


FIG. 43.


FIG. 44.


FIG. 45.


FIG. 46.


FIG. 47.

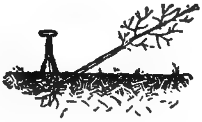


FIG. 48.


FIG. 49.

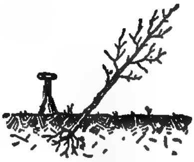


FIG. 50.

of sheet iron having a wooden handle. The one to the left for small plants is closed; the other has a hinge along its length which permits of its being opened into two halves. The plant inserted in this tube is placed in position in the ground, when the tube is withdrawn. By inserting the instrument called the "planter" in the ground, a few inches from where the tree has been planted, and using it as a lever, the earth will be well packed about the roots.

CULTIVATION OF TRUFFLES.

In a portion of the French Agricultural Department was shown what was called a specimen of the Truffle oak, which was nothing more than a small *Quercus ilex*; it is about the roots of this tree, as well as the *Quercus* (*Robur*) *Sessiliflora*, which in the extreme south becomes "pubescens," and is known as *Quercus Alba p.*, that the

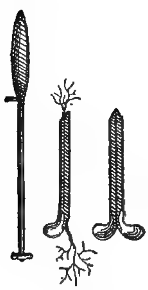


FIG. 51

FIG. 52.

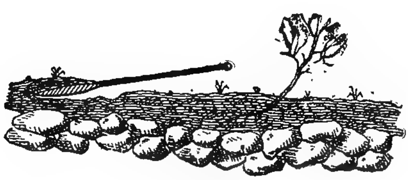


FIG. 53.

best beds of truffles are found. Considering this fact, it is pretty well authenticated, that the tree enters into the production of the truffle, but only as affording a favorable surrounding; in other words a truffle bed is unknown except in company with trees.

The constitution of the soil is also of great importance. The presence of a certain amount of carbonate of lime is essential, at least 1 per cent. The best truffle fields of the districts of Perigord and Angoumois, have a soil of a calcerous nature of Jurassic formation, and contain, in addition to carbonate of lime, sand, clay, oxide of iron, some phosphates, alkalies, with a small amount of organic matter. Of these latter elements, the oxide of iron seems the most important.

The following is the analysis of the constituent parts of two of the best truffle fields near Vaucluse; the first was amongst *Quercus ilex* and the second amongst *Quercus pubescens* (Alba).

	Bedoin.	Flassan.
Mechanical analysis.	*Per cent.*	*Per cent.*
Small calcareous stones	30	37
Physical chemical analysis.		
Water	8.53	7.35
Siliceous sand	31.75	36.60
Calcareous sand and friable chalk	17.87	14.74
Clay	37.15	38.
Humus, or black matter	4.70	3.31
Chemical analysis.		
1. Oxide of iron and alumina	9.810	9.250
2. Phosphoric acid	0.069	0.055
3. Chalk	0.507	1.330
4. Potash and soda	0.636	0.372
5. Oxide of magnesia	0.123	0.046
6. Azotic matter obtained from the humus	0.169	0.119

The permeability of the soil is also an essential feature, as likewise a good southern exposure and a warm general climate.

These truffle beds are found at their best on the sides of hills, and on the high levels not too thickly wooded; one indication is, the gradual disappearance of herbal vegetation whilst the bed is in preparation, its entire absence whilst it is in full activity, and its reappearance when the truffle production is at an end.

As to the origin of the truffle, it is now almost universally accepted by botanists, that it is a species of mushroom, finding a favorable element of development in the proximity of the roots of certain trees, but being in no way an excrescence of the same, and yet dependent upon their presence for the development of the mycelium or spawn, which, according to some authorities, finds its nutriment in the hairy portion of the roots; it is on this account that the surface of the truffle bed becomes denuded of herbal vegetation.

Truffles of some nature, are found in almost all parts of Europe having a temperate climate, as well as in England; none, however, are equal in quality to those found in the center and southeast of France.

The production of these truffle beds can be augmented considerably by artificial means, and there are various methods of forming them even where they are not indigenous.

Truffles are found a few inches below the surface. They are collected generally with the assistance of trained dogs or pigs, who receive a reward each time a truffle is exposed: the great advantage of their use, is their excellent scent, and the fact that they never disturb any but the ripe tubercles; it is important that they should not be collected too soon, nor left in the ground after arriving at maturity.

It is the pig that is most used; although slower, he is more sure than the dog; the latter by his scratching, frequently throws the truffle to a distance and makes it difficult often to find it, whilst the pig simply roots out the sought for treasure. It is stated that failing a reward, the pig refuses to continue the search.

The harvest commences in November and continues until March, and the search should be repeated every 6 or 8 days.

An artificial truffle farm, consisting of some 17 acres, produced in the first twelve years an average of under 150 pounds of tubercles, having a value of $600. The thirteenth year this rose to 600 pounds, of a value of $1,150, and continued prosperous in the same or an increased degree until the twenty-second year, when a slight decrease was perceptible, and the following year the oaks were cut down, as the production had ceased.

The annual production of truffles in France has been estimated as being over 3,500,000 pounds, representing a money value of more than $3,000,000. Upwards of 90,000 pounds were exported to England in 1885, 50,000 pounds to Germany, and some 35,000 pounds to Belgium.

This question has been referred to at some length, because it seems impossible that there should not be beds of truffles existing in many sections of the United States, and if the hypothesis is correct, a considerable source of natural wealth is neglected, for want of the seeking.

The value of the truffle as a condiment in food is well known, its nutritive qualities are equally well established, and it is only the abuse, that can cause the bad results with which it is credited. The following list of the component parts of a truffle of Cahors will justify this statement:

Composition of a truffle (de Cahors).

Water	76.60
Azote, dry matter	
Volatile or combustible matter not including azote	20.30
Azote	1.68
Phosphoric acid	0.39
Sulphuric acid	0.04
Potash	0.40
Soda	0.09
Magnesia	0.10
Lime	0.17
Carbonic acid and other matters not in sufficient quantities	0.78
	100.

The climate and soil of parts of North and South Carolina, would seem to be admirably adapted to truffle cultivation, and, curiously enough, the Ilex oak is sometimes known in France as the "Carolina" oak.

REPLANTING FORESTS.

It is important to distinguish, in examining the methods employed by the French forestry department, what is called "repeuplement" from "reboisement;" that is to say, in the first case filling up the empty spaces in an existing forest, and in the latter creating anew what had ceased to exist entirely. In other words, one is a case of restoration and the other of resuscitation. The ordinary operation of treating a large Government forest, is as regular and sure in its method, as the management of a farm; and apart from the special training required, which is received at one of the Government forestry schools, (the principal of which is at Nancy,) no great amount of initiative is exacted. But it is quite different when the difficult problem has to be solved, of replacing, on a large scale, forests which have entirely disappeared, and oftentimes in places where the scanty supply of soil, which formerly existed, has been almost entirely washed away. All the details of these operations were graphically explained at the Exhibition, by numerous photographs, mounted in albums, showing the state of the works at all stages, and a number of maps and pamphlets gave all the information necessary. For works of this nature, services of the engineer were as important as those of the forestry expert.*

In its plan of rewooding, the state has endeavored to confine itself to work strictly necessary, thus anticipating impending disaster, if left to the initiative of private owners, but offering at the same time, every possible encouragement to them, to move in their own interests.

Monsieur Demontzey, administrator of forests, prepared a pamphlet on this subject, especially for circulation during the Exposition. He commences by saying (speaking of the disastrous effects of the action of mountain torrents) that all persons competent to judge, those who have lived in these regions, are unanimous in admitting, that the principal cause of the existence of these torrents, is from the destruction of the woods which formerly surrounded their source of supply. An eminent authority has formulated the following proposition:

1. The existence of the forest prevents the formation of torrents.
2. The destruction of a forest leaves the soil at the mercy of the torrents.
3. The development of the forests tends to prevent the action of the torrents.

In a report made to the Government in 1866 the condition of the Basses Alpes is referred to in the following terms:

In the place of the grand forests and rich pasture grounds which, according to the tradition of the inhabitants, once covered these sites, nothing is seen but bare

*See "L'Exposition Universelle," by Henri de Parville 1890, on pages 556 to 574. for views of the works undertaken by the French Government, to control certain mountain torrents; also a description of the same, and of replanting and development of forests.

summits and sterile flanks, torn in every direction by the action of torrents, and here and there barely enough earth to sustain a few wretched shrubs, deep ravines below into which the torrents have projected avalanches of rocks and gravel. At long intervals a few hamlets are met with, where a hardy and industrious people defend with difficulty their poor heritage, against the attacks of storms, inundations, and other causes of destruction. Among them continues slowly but surely the work of devastation, commenced more than a century ago or since the existence of laws, that have permitted the destruction of these woods and mountain pastures.

Referring to the region of the Cevennes, he says, the absolute absence of forests on the summits and about the sources of the water courses is the characteristic feature of this region; they are even more rare than on the Alps. In the district of Saint Pons (Herault) in 1875, a violent storm occasioned an inundation in a few hours, which carried away 150 houses and mills, and destroyed the lives of 100 persons.

In the Pyrenees the situation was a little better, owing to the existence of forests in greater numbers, and a greater relative amount of care. The torrents are there more rare, but there is no time to lose if these mountains are not to fall into a condition like that of the Alps. As it is, it is easy to recognize that many torrent beds are of recent formation, and plainly traceable to destruction of forests in their neighborhood.

The whole region embraced in these three districts, comprises twenty-nine departments, and represents one-third of the territory of France.

After the experience of the application of several different laws, having for their object the remedy of this situation, all of which were found ineffectual in part, in 1882 a series of acts were passed, which have for a result, a marked improvement in the condition of these districts.

The state, after the most careful and thorough surveys, has designated certain portions of this territory, as being subject to their supervision for the public good, and in others it has purchased the lands outright; so that the position at present is as follows: The supervision extends over an extent of special districts aggregating about 750,000 acres; to-day, by the work already executed, the acreage is reduced by fully 150,000, so that one-fifth of this gigantic undertaking is already completed.

In order to conquer these torrents, and render them harmless for the future, it was necessary to bind them by a continuous band of vegetation, and hold them firm in the thousand arms of a forest, the only athlete strong enough to control them.

Twenty years have passed since this work was first commenced, and to-day, on the high plateaus of the Alps and Pyrenees, and even above the site of the existing forests, may be seen vast tracts of resinous trees suited to the rigorous climate; not only at the reservoir

of supply of the first torrents which were attacked, but high up to the very source itself the borders are fixed and bound forever, whilst the torrents themselves, formerly so terrible, have become simple mountain streams, not only without danger, but of inestimable use to the agriculturist of these regions.

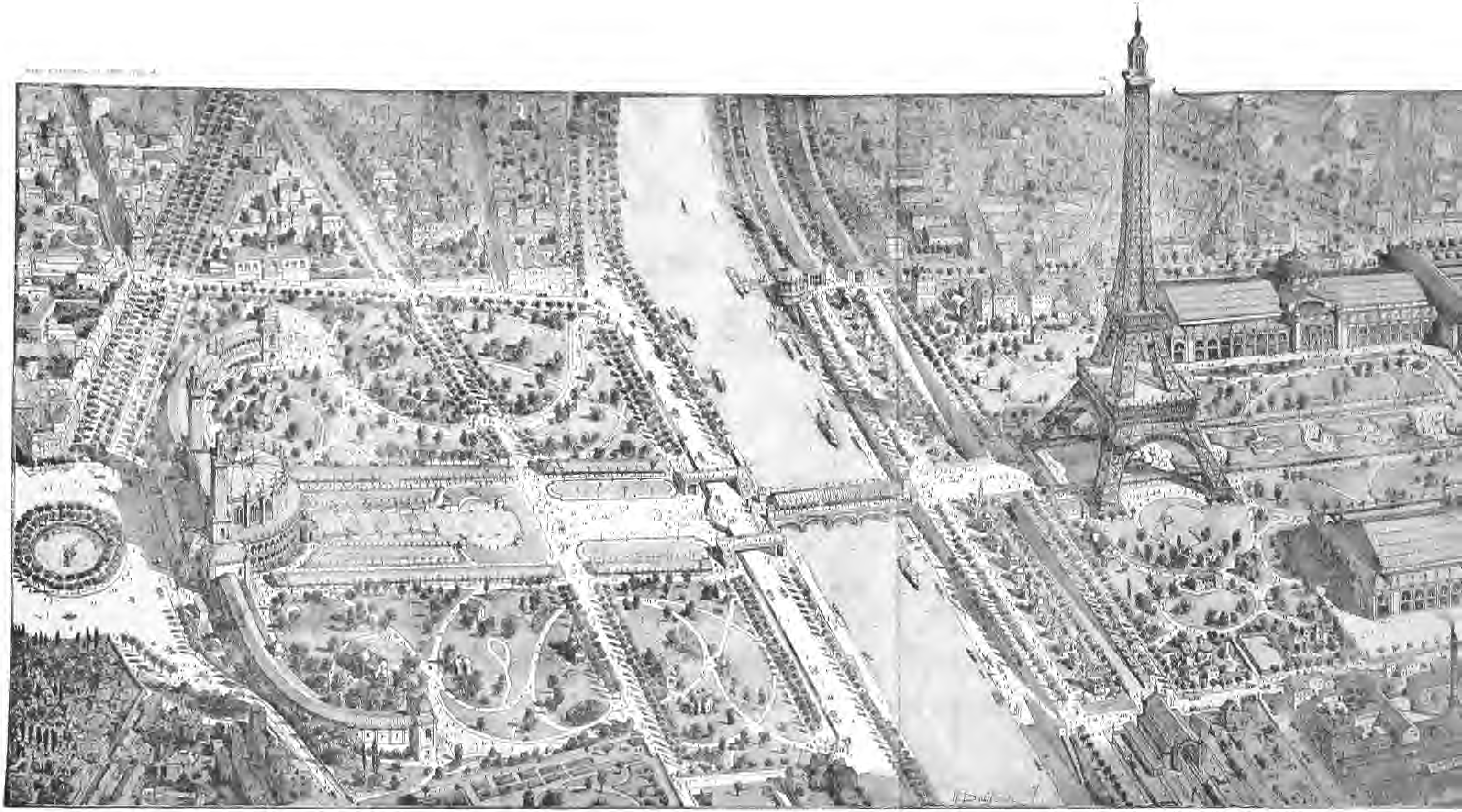
The facts have largely proved that the solution is neither difficult to obtain, nor one involving great delays, and it suffices to aid nature in her work by a consistent use of the means which experience has taught.

The 360,000 acres of new forests, which cover at present the Alps, the Cevennes, and the Pyrenees, where before all was bare and barren, can inspire confidence in the future, and their vigorous vegetation, proves the error of those who declared the enterprise useless and vain.

While much of the information herein given may already be familiar to experts in horticulture, my instructions remind me that the report is intended for the people of the United States. I have, therefore, confined myself to statements and descriptions likely to be of practical benefit.

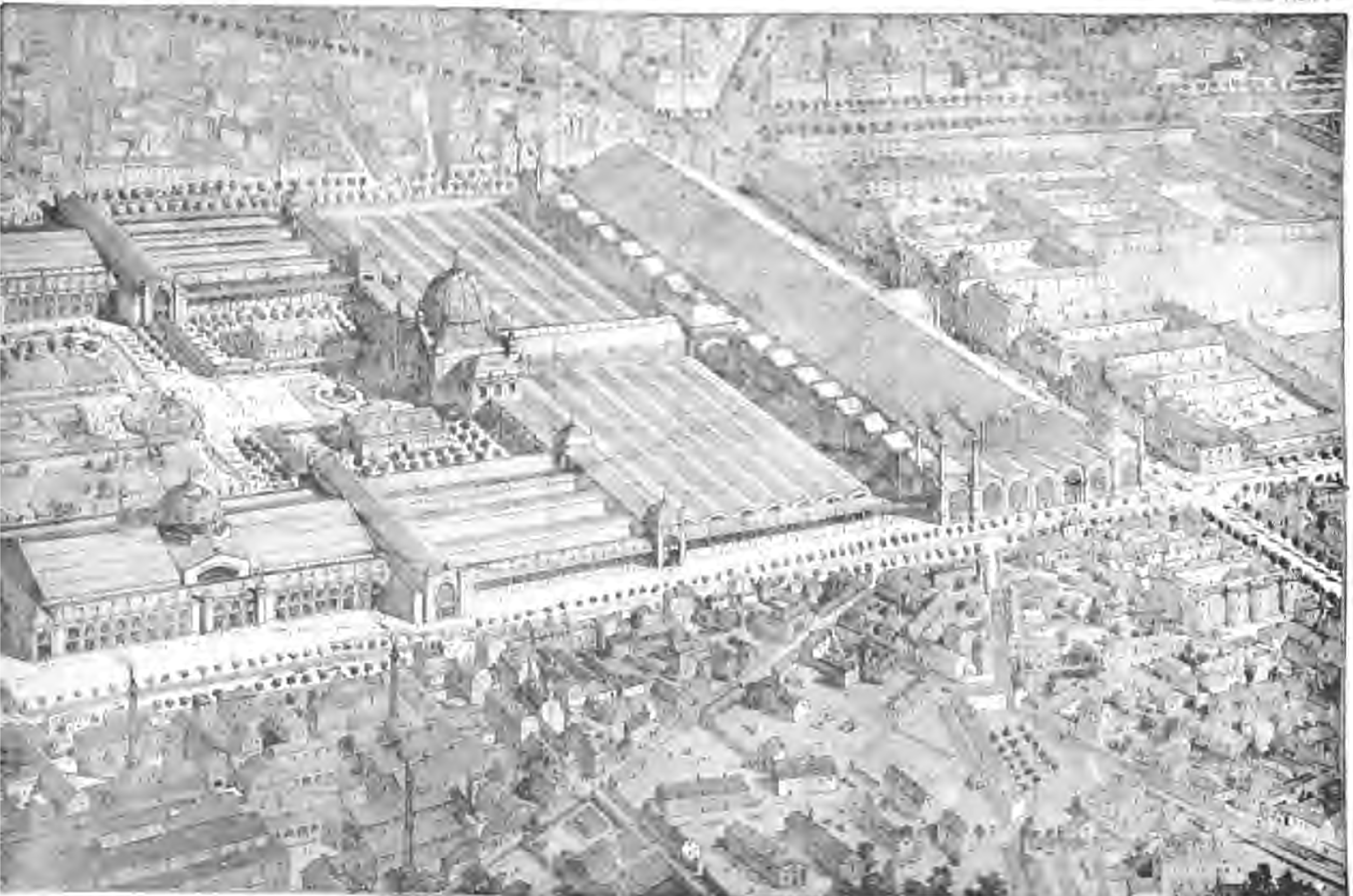
Most of the matter appeared in some form in the Exhibition, and it will be easy for our people to discern which, if any, of the plans and methods given, should be adopted and applied to our own industry.

It affords me much pleasure in concluding this report, to acknowledge the valuable assistance rendered by Albert Chevalier Haseltine, esq., of Philadelphia, who, from his long residence in France, and by his practical experience, greatly facilitated my researches.



TROCADERO PALACE AND GARDEN

GENERAL VIEW OF THE EXPOSITION



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